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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **700** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE CARE AND MAINTENANCE OF METERS AND THE EFFECT ON REVENUE.

BY A. W. CUDDEBACK, SUPERINTENDENT AND ENGINEER, PASSAIC WATER CO.

[*Read September 10, 1913.*]

With the coming of government regulation of water rates through the public utility commissions, and the basing of these rates by the commissions upon a valuation of the property, the need for careful and economical operation of water departments will be emphasized, and a careless, slipshod manner of doing business will be likely to land the water company or department in financial difficulties.

It becomes important under these conditions to conserve the water supplies already developed, and to this end the selling of water by meter will receive an impetus. The flat or annual method of charging for water has its advantages and its disadvantages, and among the chief of its disadvantges is that there is no immediate individual penalty to follow the wilful or careless waste of water, and the inevitable result is that a large percentage of the water delivered to a community under this system is, unless there is maintained an exceptionally efficient and constant inspection, wasted through leaky fixtures.

The advent of the meter as a means of measuring water delivered to the customer and to determine the amount he should pay for service in accordance with the amount delivered into his premises should check the needless waste going on under the old method; but, in order that the meter may completely accomplish this desired

result, it is necessary that it should be at all times in good condition and adjusted to the work it is to perform. In other words, it must measure accurately all of the water entering the premises, or it fails in its principal purpose of checking waste and placing the charge for water where it belongs on the user or waster, as the case may be.

It is not enough that a meter should register accurately at the time it is put into service. It should first be suitable for the service it is to perform, i. e., it must be of the proper size and type for the particular work it is to do. The determination of the type and size for the ordinary domestic service is not difficult, but in a water system of any size there are many services that require some study to determine the proper meter to secure the best results. In large factories the use of water may be so varied that no single service can be equipped with a simple meter to satisfactorily and accurately measure all of the water. The interests of the consumer and the water department are sometimes antagonistic in these cases; the consumer demands a large full flow at times, while at other times only a small flow is demanded, and in many cases a fire protection service is also expected from the same source. It is obvious that the water department cannot hope to satisfy all of these demands, and still economically and efficiently as well, measure the water through one instrument. All of these considerations show the necessity of a careful determination of the type and size of meter to be used, and necessitates the decision of a man who not only knows the conditions to be met with in each particular case, but one who knows just what results can be accomplished by the use of different types and sizes of meters.

After these preliminary questions of type and size of meter are determined, the work of the intelligent meter-man is just nicely started. No sense of false security should now be allowed to abate the activity with which he should follow up and watch the performance of the instrument that he has set to determine the money that each water user must pay for the service rendered to him.

The dishonest water user who will tamper with the meter (for there are a few of these in every community) is not the enemy to cause the most worry, although he needs attention, and the various

ways by which he can affect the registration of the meter should be known to the wide-awake meter-man. The condition of the ordinary service meter should be carefully watched, and to do this intelligently and effectively requires not only experience and a knowledge of the character of the service to which attached, but careful, continuous, and painstaking work on the part of the man responsible for the condition of the meters.

The methods by which we determine the meters to be removed for test, and keep ourselves informed as to the performance of individual meters, will be given in some detail, as we consider it of great importance, and some of the results shown justify these conclusions.

The readings of the meters are taken on loose-leaf slips, which always have on them at least a year's record of the consumption at that particular property, and on an average the record for a much longer period. On the back of this slip is noted the character of the property supplied; a record of the number of families; important fixtures, business, etc., any information that may be useful to the meter superintendent in helping him to arrive at an instant conclusion as to whether the meter is performing its work or not.

We aim to maintain not only accuracy, but a sensitiveness close enough to measure the innumerable small leaks that occur in plumbing fixtures, and to do this requires unceasing and careful study of the various conditions under which the meter is operating, and it follows that close watch of their work while in service must be given by an efficient man to insure a reasonably full registration of the water.

A falling off or an increase in the quantity of water registered by a certain property immediately calls for an explanation. Oftentimes the explanation is found on the slip. If the meter reader has been properly instructed and is conscientiously doing his part of the work, he has already noted the change in consumption and made inquiries or tests to determine the reason.

No attempt is made on the first or regular reading to ascertain the accuracy of the meter, as too much time is required, and the routes would come in unfinished, each route being made up on an average of 120 readings, which is considered a good day's work.

The aquaphone, however, must be used in every instance on the first reading. This is an invaluable accessory to the meter department. Each inspector is required at all times to carry one and after a reading of the meter is taken, contact is made to the meter or pipe near the meter to determine whether any water is passing that is not being registered. The record of this observation is indicated directly to the left of the reading by simply an "S" for still, "L" for leak, and "R" for running. In all cases the slips marked "L" and "R," where the quantity is not above normal, and all other records of doubtful quantities, are laid out for verification of readings and thorough investigation. On these "back calls" the aquaphone is again very useful in determining definitely whether an actual leakage exists without first inspecting all the plumbing. Time can be taken on these second calls to determine whether the "L" noted on the first reading was due to the final filling of a closet tank or an actual leak. Should there be a leak, the meter is timed for one tenth of a foot, if it is sensitive enough to record it, and if not, it is so stated on the inspection blank, and the meter is promptly taken out. In either case an inspection is made and the leak located. It is not uncommon also for the inspectors to report a leak which they estimate the meter is not fully registering. Where no leaks exist and the consumption is below normal, the meter is tested out for sensitiveness by attaching an orifice to a hose bibb or faucet, which is to be found on most any premises. This orifice passes a stream approximately equivalent to the average closet leak, allowance being made for difference in pressure of the various sections; the time required to register one tenth of a foot, or the fact that the meter failed to record it, are all noted on the slip directly opposite the reading.

We believe that very few faulty meters are missed during a reading that give the slightest sign as to their condition. All meters that will not register the average closet leak, or 300 gal. per twenty-four hours, are marked by the inspector for the attention of the superintendent, as we are satisfied that such small flows go to make up a large part of the total consumption.

During the meter reading period, the slips are turned in daily, and as stated are examined carefully by the meter superintendent, and the subtractions checked in ink. He makes a list for further

TABLE 1.

Record of Ten $\frac{5}{8}$-inch Disk Meters.

Dates.	Quantity Registered by Quarters in Cubic Feet.									
	1	2	3	4	5	6	7	8	9	10
1906–April	....	....	....	....	3 700	.....	.....	....	....	....
July	....	....	....	....	3 900	.....	.....	....	....	....
October	....	....	....	....	1 900	.....	14 200	....	....	....
1907–January	....	....	....	....	3 200	.....	22 500	....	....	....
April	....	....	....	2 200	2 800	.....	21 100	....	....	2 600
July	....	....	....	2 100	2 900	.....	12 900	1 600	....	1 500
October	....	....	....	3 100	1 700	.....	13 000	1 700	....	1 500
1908–January	5 000	....	2 200	2 800	2 500	8 500	12 900	2 100	....	1 600
April	1 600	....	4 300	2 500	2 500	6 900	11 900	1 800	....	1 700
July	2 100	3 300	2 300	3 100	2 600	1 000	5 100	2 100	....	1 800
October	2 500	4 000	1 900	3 000	1 700	4 600	7 700	1 400	....	1 500
1909–January	2 700	3 800	2 000	2 700	1 800	1 100	10 200	1 800	5 600	1 500
April	2 800	3 000	2 100	2 500	1 900	1 000	5 600	1 400	4 800	1 300
July	2 600	2 600	3 100	3 000	2 300	21 900*	4 700	1 100	5 400	1 600
October	2 500*	1 300	2 500	2 900	5 000*	24 600	15 200*	1 100	5 800	2 400*
1910–January	3 700	1 600	2 500	2 600	4 600	20 400	18 600	2 000*	3 500	2 400
April	4 200	1 300	2 800*	1 900	6 300	15 200	27 100	2 300	3 900	2 500
July	5 000	2 500*	4 500	3 100*	4 600	21 800	15 600	2 500	3 500	3 200
October	5 600	4 000	4 500	5 100	5 200	22 800	13 800	2 500	3 300	2 500
1911–January	3 900	3 400	4 800	4 100	5 300	20 700	12 700	2 200	5 500*	2 700
April	3 600	4 300	4 200	3 300	5 600	22 300	19 400	2 700	5 100	4 100
July	4 500	5 500	4 800	5 000	5 200	21 700	13 200	3 900	6 300	3 200
October	....	8 000	6 900	4 700	5 500	22 700	13 200	2 100	5 300	2 500
1912–January	....	2 300	6 300	4 700	5 200	22 000	9 600	2 200	6 400	3 300
April	....	2 300	5 200	4 300	....	25 700	19 400	....	6 700	3 700
July	....	....	5 900	5 200	....	27 200	15 400	....	7 000	....
October	....	....	4 000	4 600	....	21 700	24 600	....	6 300	....
1913–January	....	....	5 200	4 400	....	26 600	15 000	....	....	....
April	....	....	4 300	4 600	....	24 000	15 600	....	....	....
July	....	....	4 900	5 100	....	21 100	.....	....	....	....

* Indicates new meter.

examination and test in the field, and finally, from all the information turned in by the inspectors, the performance of the meter as indicated by the registration, and from his knowledge of the character of the property served by the meter, he determines at each reading the meters to be removed for test. This list is turned over to the plumbers or meter repair men for immediate attention as soon as a district is gone over, so that the removal of doubtful meters is going on continuously. After the reading and inspection, property owners are notified by postal of high consumption, and if the inspection shows the trouble, this is called to his attention. In this way not only are the bad meters removed promptly, but property owners are as promptly informed of leaks which cause waste and high bills.

To illustrate the method of arriving at meters to be removed and the results obtained, we have taken the record of ten meters, shown in Table 1.

Record No. 1 gives a total for seven quarters of 19 300 cu. ft. for the original meter and 28 500 cu. ft. for the first seven quarters on the new meter, or an increased registration of 50 per cent. In this particular case it was the period of service and not the record of registration that led us to remove the meter for test.

Record No. 2 shows a falling off in registration sufficient to excite suspicion, and a comparision of eight quarters gives 20 900 cu. ft. for the old meter, and 32 300 cu. ft. for a corresponding period for the new meter, or 54 per cent. increase in registration.

The third case shows an increase of almost 100 per cent. in registration.

The fourth column shows a meter caught early in its period of deterioration, but which shows for the first year of the new meter a gain of 50 per cent. in registration over the last year of the old meter.

Record No. 5 shows an example not so clear, but when corresponding quarters of succeeding years are compared, the record looks suspicious, and the record of the new meter justifies the conclusion that the meter was ready for removal for test, the new meter for the first year registering 170 per cent. more water than the old meter during its last year's service.

No. 6 gives a maximum of increase, and illustrates the possi-

bility of missing some poor meters for a long period, even when the greatest care is taken in the examination of the records. Here the increase for the year and a half shown is 450 per cent.

No. 7 shows an erratic consumption with a marked falling off, with an increase in registration for the year of 180 per cent.

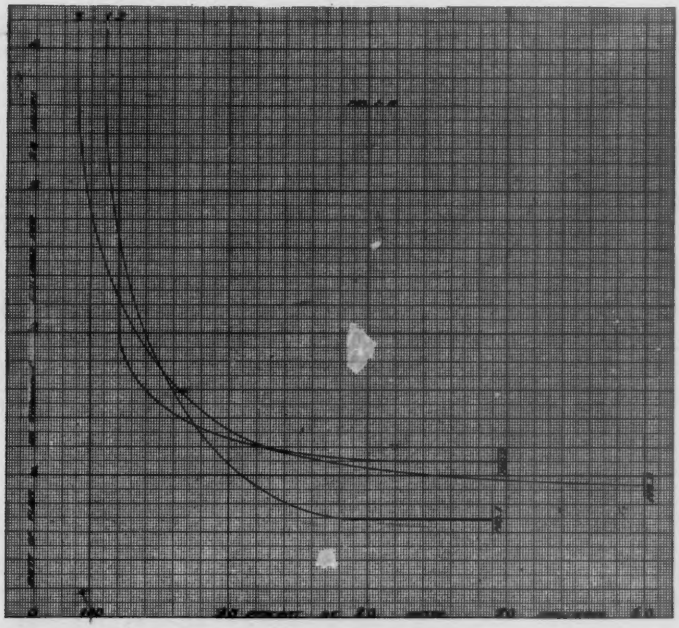

FIG. 1.
TESTS OF METERS REMOVED.

No. 8 shows a gradual falling off in registration, with about 100 per cent. increase.

Nos. 9 and 10 are typical cases of gradual falling off in registration, and the usual increase with the installation of a new meter.

Not all of the meters removed for test show a falling off in sensitiveness, but fully 75 per cent. of all selected are ready for over-

hauling, and the subsequent registration of the new meters shows results of which the examples given in Table 1 are typical. The conditions under which these meters were working did not change during the periods given, so the record shows a true comparison between the old and new meters.

To further illustrate graphically the necessity of watching the meters closely, and the results obtained when changes are made,

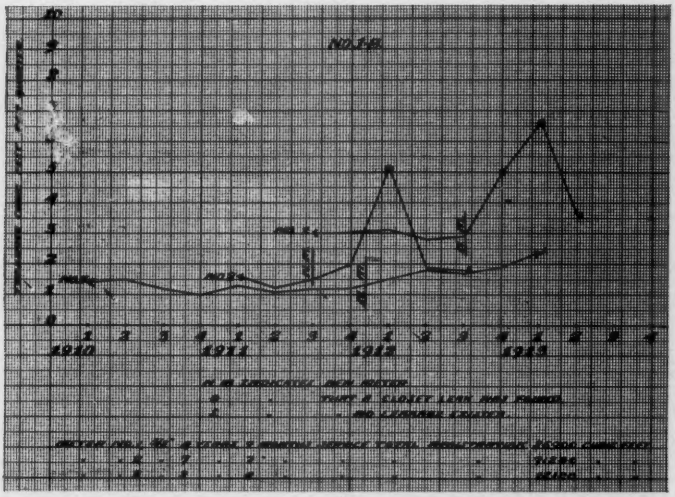

FIG. 2.
SENSITIVENESS OF METERS REMOVED.

we have selected three typical cases, and Fig. 1 shows the test of meters removed, and Fig. 2 the registration of these meters and their sensitiveness. These meters are numbered 1, 2, and 3, for convenience.

No. 1 would not register on test a stream of 650 gal. per twenty-four hours, and its record curve for five quarters preceding its removal shows a uniform registration of about 3 000 cu. ft. per quarter. This meter came under suspicion by a comparison going further back than is shown on the curve. The record of the

new meter shows a decided increase of registration for two quarters, with a dropping back in the third quarter. The increase in the first and second quarters was due to leakage, which if the normal use was from 3 000 to 4 000 cu. ft. per quarter, amounted to from 2 000 to 3 000 cu. ft. per quarter, or from 200 to 250 gal. per day, a flow that was below the point of registration of the meter that had been removed, and this leak would not have been registered by the old meter. As a matter of fact, the leak had in all probability been going on for some time before the change of meters was made.

Meter No. 2 would not register on test a flow of 1 100 gal. per twenty-four hours, and consequently would not record a leak less than this amount. In this case the consumption record shows an increased registration of only 500 cu. ft. for the first quarter of the new meter, but catches a leakage of 3 000 cu. ft. per quarter during the next period, which in all probability the meter removed would not have picked up. The record seems to show that the normal registration has been increased from 500 to 1 000 cu. ft. per quarter by this change.

The curve of Meter No. 3 shows a registration down to about 1 000 gal. per twenty-four hours, and the record curves of this and the meter that replaced it, show a gain in one year of about 1 000 cu. ft. per quarter.

CAUSE OF LOSS IN SENSITIVENESS.

There are many causes contributing to the deterioration in effectiveness of the meter in service, — the gradual wearing of the working parts; clogging up by foreign substances such as white lead used by plumbers in the installation of service pipes; scale from service pipes; dirt stirred up in the distribution system by reversal of flows; flushing of pipes; dirt getting in pipes when extensions or repairs are made; etc. All of these things have their effect on the domestic meters. It remains for us to minimize the effect of these various causes of trouble by using care that little dirt gets in the pipes during construction, by flushing during periods when the house draft is at a minimum, by thoroughly flushing out service pipes when new meters are set, by avoiding the use of every material in the installation of service pipes that will clog a meter, and by the selection of the best type of meter for

particular services. In effect, to have in mind in all of our operations of the water plant, the possible effect of such operation on the meters, which must be kept in perfect condition if we are to get the best service possible from them.

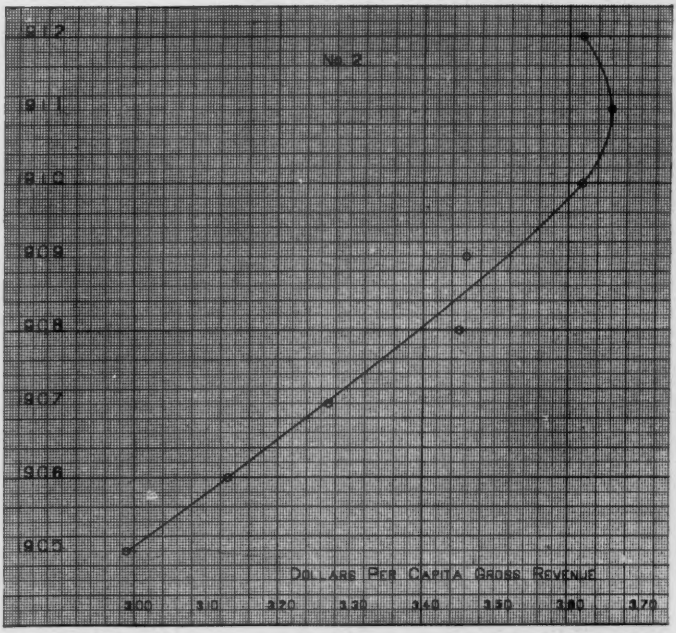

FIG. 3.
GROSS REVENUE PER CAPITA.

Now that we have considered the methods of caring for meters, the effect of neglect or proper care on their registration, the causes effecting conditions, and methods of minimizing deleterious effects, we will attempt to show the result of several years of careful attention to domestic meters on revenue.

Figure 3 shows gross revenue per capita for a period of eight years. This is the record of a residential town of about 24 000

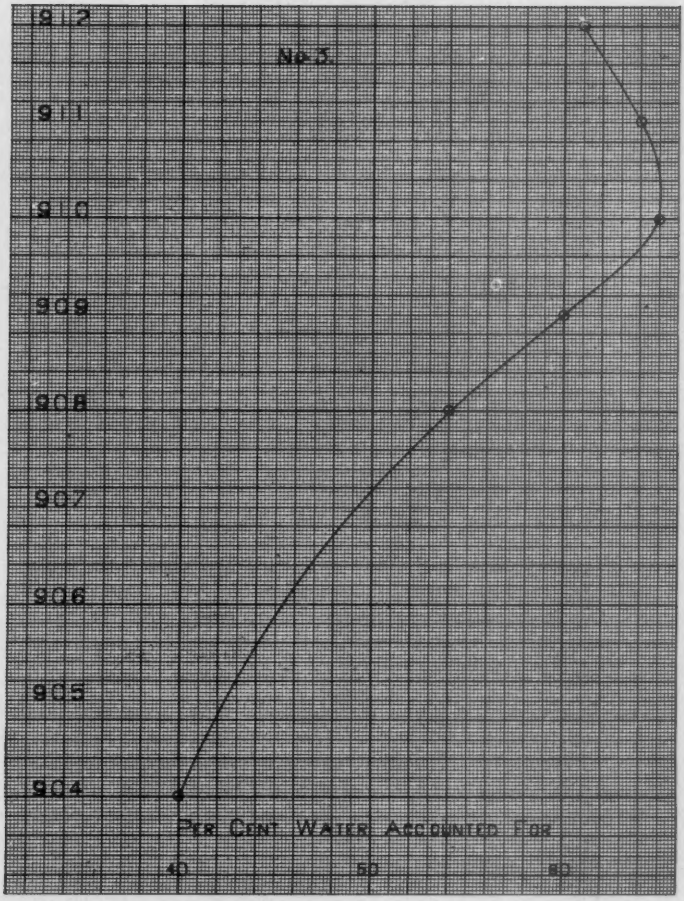

Fig. 4.

Per Cent. of Water Delivered Registered by Meters.

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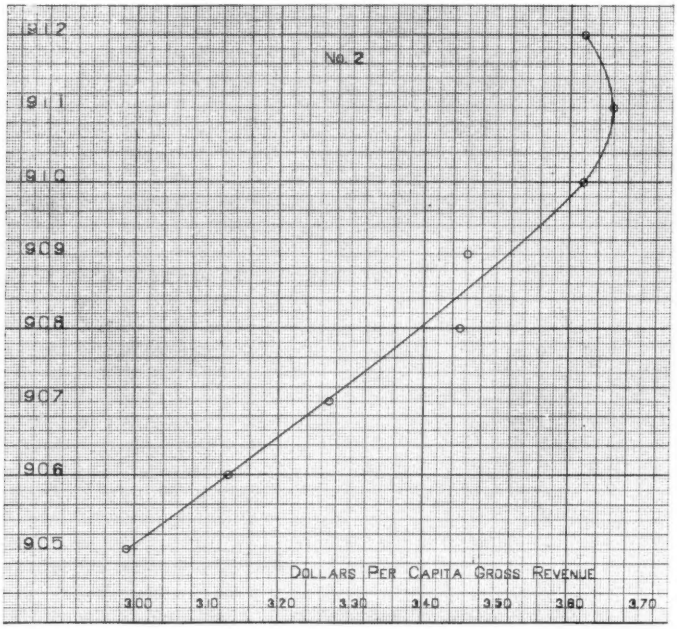

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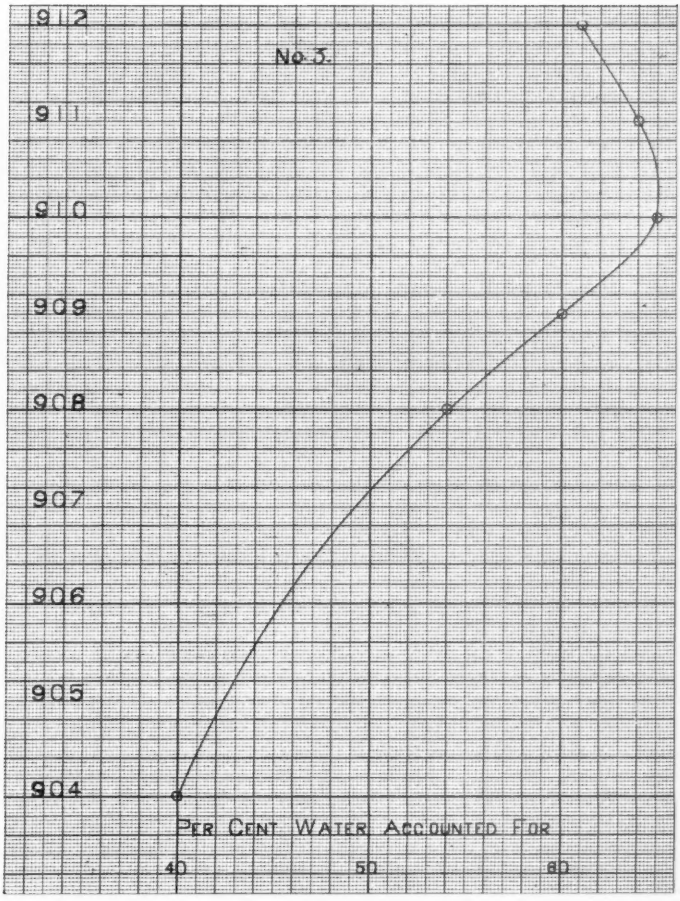


Fig. 4.

Per Cent. of Water Delivered Registered by Meters.

population with 4 200 meters in service in 1912. The town was completely metered in 1898, and between that time and 1906 no special care was given to the meters, except to remove one when it was stopped. About 1906 we began to give the meters more careful attention, as we then had in service in our various plants enough meters to require the whole time of one man to properly look after them. The results obtained in these early attempts to better conditions led us to make a very careful study of the subject, and conditions kept improving until 1910, when they seemed to indicate that we had arrived at about the normal condition, and the one that we should hope to maintain. The curve shows very well the growth of our knowledge about how to care for meters, gained through several years' experience. While we do not claim that the care of the meters was the only element entering into the raising of the gross revenue per capita, as shown by this curve, it was in our opinion the chief cause.

All of the connections in this town being metered, gave us an opportunity to make a comparison between the total registration of the domestic meters and the total quantity of water delivered to the town which was registered by Venturi meters, and since 1908 such comparisons have been made. One comparison made in 1904 enables us to plot this curve from that date. We are not at all proud of this record, as shown on Fig. 4, as the percentage of water accounted for is entirely too small. The conditions are particularly hard, — the distribution system being large in proportion to the population supplied, and the pressure ranging as high as 130 lb. A portion of the system is under direct pumping and the pressures are raised for fire service. Like the revenue curve, the care of the meters was not the only influence that affected this result, as during this period considerable work was done in detecting and stopping leaks in the distribution system and service pipes.

We consider this curve is worth showing in connection with this subject, in that it practically parallels the revenue curve, and we believe confirms our conclusions drawn from it.

In conclusion, we wish to say that the matter treated here is of necessity, to a certain extent, a repetition of the paper written for the New Orleans convention of the American Water Works Asso-

ciation, and is intended to show the practical result of following out the method of handling meters as described in that paper, and brought to date in this. It is written as a record of actual experience with the hope that it will be of some interest and benefit to the members of this Association.

DISCUSSION.

MR. THEODORE H. MCKENZIE. Mr. President, I would like to ask Mr. Cuddeback what the rate was per thousand gallons where the amount was about $3.40 to $3.60. Also, how often he tests meters.

MR. CUDDEBACK. The rate is 30 cents per thousand gallons. We test all meters when they are first installed. We do not remove them for regular tests at any stated time. I have studied the subject very carefully and have come to the conclusion that the way we are handling it is the better method, rather than watching the performance of individual meters. If we adopted this latter course we would of necessity practically have to take out every meter over the course of eight or nine years.

MR. MCKENZIE. Do you allow the meters to be set vertically?

MR. CUDDEBACK. No, I do not allow them to be set vertically. I require them all to be set horizontally.

MR. JOHN C. WHITNEY. What rate would you call an average registering rate for a meter?

MR. CUDDEBACK. Why, I think a meter should register between three and four hundred gallons every twenty-four hours.

MR. WHITNEY. I think you are stating it rather high.

MR. CUDDEBACK. Well, perhaps I am. I have made measurements of that with different meters, and we are pretty well satisfied if we are getting 300 gallons in twenty-four hours.

THE PRESIDENT. I think this matter of revenue is one that is often lost sight of. Perhaps it is not so important in the municipal plant as it is in the privately owned plant.

MR. WILLIAM F. SULLIVAN. Mr. President, I would like to ask what effect the metering has upon the revenue. That is, what is the effect upon the revenue of abolishing flat rates and

adopting the meter system? I would also like to hear from some of those men who have given this matter attention.

Mr. Cuddeback. I have had an opportunity of comparing towns similarly situated, — say, towns of a population of 100 000 — one completely metered and the other only partially metered, — and I have found that the revenue was about the same. I think the gross revenue is somewhat decreased by the installation of meters. There are many elements, however, entering into this question of whether the meter rate is comparable with the flat rate. I think that probably as a rule our meter rates are lower than our flat rates for the same service; and we get some of our reduction in revenue from that cause. My experience, however, is that net revenues will not be reduced by the installation of meters, but gross revenues may possibly be reduced. That seems rather strange, but we must take into consideration that the expense of installing meters and reading them and caring for them is offset by other expenses that are stopped when meters are installed. In a well-conducted plant, for instance, we should have a reasonable amount of inspection if we are going to keep our water consumption down. That expense offsets the meter reading and perhaps a good share of the care of the meter. There is also considerable expense saved in the reduction of pumping and additional investment for the plant to take care of increased consumption.

Prof. Philander Betts. Mr. President, I think another answer to that is that the result of adopting meters depends somewhat upon the class of customers who are metered at first. In Long Branch the Public Utilities Commission of New Jersey ordered the water company to install meters in connection with service to all hotels, bathhouses, industrial concerns, stock farms, greenhouses, and in all cases where the conditions were special. Without exception the bills were very materially increased after the meters were installed, but that was due to the fact that in all these special cases customers were using quantities of water far in excess of what the ordinary flat rates would pay for. In other words, before these meters were installed, there had been discrimination practiced in favor of these customers. I do not mean that the company was doing this with any idea of favoring them,

but that the ordinary flat rate schedules will not take care of boarding-houses, hotels, industrial establishments, dairies, steam laundries, and stock farms, and if properly applied, flat rates will produce gross bills so high that it will occasion considerable dispute. In Long Branch the disputes due to the increase in practically all of the bills to these different customers have not yet ceased.

The Long Branch Company meters very few customers. The business is very large, and it has practically all been carried on at a flat rate. The company is receiving a very large revenue, but notwithstanding that, the amount of money that is actually left over for net income as a profit on the investment is very small. The company has just been able to pay an ordinary interest rate in the last few years. The solution of that company's difficulties lies finally in the adoption of meters for all service. What will then result in connection with the majority of customers (beyond those to whom meters have already been applied) will be, to my mind, without question, a reduction in the gross revenue. There will also be a very material reduction in the operating expenses, with the probable result that the company will have more money left over with which to pay the interest on the investment.

The case of the Long Branch Company is typical of that of a good many who have hesitated for years in the adoption of meters. I mention this point regarding this particular company because we have probably had more complaints against that company than against any other company in the state of New Jersey. In this connection it is shown that the conditions there are due very largely to the lack of meters.

There must invariably be a period of a great deal of trouble in any situation like that; but in perhaps a year or so after meters are once installed the customers become used to them and adapt their water usage accordingly, and then the conditions are very much better than before. To show the contrast, I might say that in another set of companies with which Mr. Cuddeback is very familiar, where the great majority of the customers are metered, there have been practically no complaints at all in regard to the bills rendered.

MR. CUDDEBACK. Mr. President, our experience in Paterson in comparing rates has been this. For the last fifteen years we have been metering all new connections, and those applying for meters. In those applying for meters during that period, about 90 per cent. have had a reduction in their annual water bills by the installation of meters, as against the flat rate bill that they formerly paid. That is the only comparison we could make. But in looking at those figures we must take into consideration the fact that only those customers applied for meters who thought that they could make a reduction in their bills by having meters installed.

MR. GEORGE A. KING. I think that Mr. Cuddeback has given us some excellent practical points in connection with the care of our meters, but to what he suggests I would add a periodic testing and cleaning of the meters. A meter may begin to go slow and go down to recording only 50 per cent. of the actual consumption before the fact that it is going slow is noted, with the periodic testing of meters that may be overcome. I think that this should be added to Mr. Cuddeback's list of the care to be given meters.

MR. CUDDEBACK. A meter is almost as apt to go slow within a year after it is set, or go wrong within a month after it is set, as it is to do so within two years or three years. That is, the period which you select to take out your meters for general testing would not reach any appreciable percentage of those that go wrong, and you get better results by carefully watching the individual performance of the meters. A great many meters are taken out within a year after they are set. I feel that some rule like this might be applicable: Say, within a period of eight years (just to set a time) any meter that has not been overhauled during that period should then perhaps come out.

MR. KING. I would make it four years.

MR. W. C. HAWLEY. While discussing this matter of meters I would like to ask if any one has had the experience such as we are having at the present time, of meters running fast. Since we have installed our filter plant we have been up against that proposition, particularly within the last nine months or a year. Prior to that time I believed — and I have expressed the opinion a

great many times — that practically no meter over-registered if it has been properly tested before setting. But I have been obliged to change my mind on that subject. It is not true of all the makes, but we have two makes in particular that we have been having trouble with. It has become so serious that we are taking out every one of those two makes, bringing them to the shop and retesting them. As far as I can tell, it is a case of the disk not fitting the disk chamber closely in all parts of its oscillation. The meter is tested, and put in registering properly; by and by that space between the disk and the disk chamber begins to fill up with silt or an organic growth, and that meter will run three, four, five, and in very exceptional cases 12 per cent. fast. When a customer kicks about his bill and you test his meter and show him that it is 10 to 12 per cent. fast, there is trouble.

THE PRESIDENT. That's an extraordinary thing in my experience, for a water meter to run fast.

MR. FRANCIS T. KEMBLE. We have had some experience in that way, the chamber filling with sediment, — particularly in low spots where the sediment would amount to something, — and the meter running just about that point — three, four, or five per cent.

MR. JOHN C. TRAUTWINE, JR. The author's diagrams, Figs. 3 and 4, are beautifully convincing as to the beneficial results of "The Care and Maintenance of Meters" between the years 1904 or 1905, and the years 1910 or 1911; but, beyond the latter point, each curve seems no less convincing as to the inauguration of a period of retrogression, and I must congratulate the author upon the optimism which has enabled him apparently to overlook this feature.

Referring to Fig. 3, the author says: "Conditions kept improving until 1910, when they seemed to indicate that we had arrived at about the normal condition, and the one that we should hope to maintain."

Referring to Fig. 4, he says, indeed: "We are not at all proud of this record, as shown on Fig. 4, as the percentage of water accounted for is entirely too small"; but this seems to refer to the diagram as a whole, and merely to admit that from 40 to 65 per cent. of water accounted for "is entirely too small."

Neither reference makes any allusion to the rather obvious drop in the curve, beginning at about 1910 or 1911.

MR. CUDDEBACK. The curve is on such a scale that the variation in the last three years is only two cents per capita. The variation in the period from 1906 up to 1910 is some 45 cents per capita. I think perhaps that answers you.

I didn't dwell with any optimism on that second curve. I simply showed it to show how bad the distribution could be.

I might say, Mr. President, that we have had a very few examples exactly like Mr. Hawley describes; nothing that can be described as an epidemic, but we have had individual cases where meters over-registered as high as 6 per cent., and I judged from the same causes exactly as he gives. But it was nothing of a serious nature, not nearly one per cent. of the meters over register.

MR. MCKENZIE. How do you determine that they over-register?

MR. CUDDEBACK. By a volumetric test.

CLEANING WATER MAINS AT HARTFORD, CONN.

BY CALEB M. SAVILLE, CHIEF ENGINEER, BOARD OF WATER COMMISSIONERS, HARTFORD, CONN.

[*Read November 12, 1913.*]

The city of Hartford, Conn., is supplied with water by gravity from a system of six reservoirs in West Hartford, distant about 6½ miles from Hartford City Hall. Nearly twelve miles of watershed are tributary to this system, the drainage from all of which finally flows to Reservoir No. 1. The effluent gatehouse is located at the base of the dam of this reservoir, and from it lead the three mains which supply the city, two 20-in. and one 30-in. The first main laid was of the well-known cement-lined character, and was put into service in 1867. On account of frequent breaks, portions were replaced from time to time with cast-iron until now this is wholly a cast-iron line. Although the older in point of original location, this main is actually the lesser in age of the two 20-in. mains. In speaking of this main hereafter, it will be known as the south 20-in. main. The other, known hereafter as the north 20-in., was laid in 1875, and is therefore about thirty-seven years old. The 30-in. main was laid in 1896 and is sixteen years old.

The average consumption for the year 1911 was at a rate of 8 051 000 gal. per day. The maximum monthly rate in 1912 was 9 245 000 gal. per day, the maximum rate at any period during the day being about 13 700 000 gal., while the minimum flow from midnight to 5.00 A.M. was at a rate of 4 500 000 gal. per day. The drop in pressure at City Hall due to this difference in rate was 18 lb. before cleaning, and the gain due to the cleaning of one 20-in. main is estimated to be from 2 to 3 lb., the actual loss with the same flow under present conditions being from 15 to 16 lb. For the preliminary study, simultaneous measurements were taken in all three of the mains at the time of average daily flow. Previous to these tests the 30-in. Venturi meter on the supply line and the pitometers used in the work were checked against each other, the pitometers being found to read about 1.5 per

cent. in excess of the meter reading. The results of the preliminary tests on the mains have been summarized and are given in Table 1, together with certain comparisons that relate to age, carrying capacity, and present conditions of these supply mains:

TABLE 1.

Diameter.	When Laid.	Coefficient for Kutter's Formula as per Weston.			Discharge in M.G.D. Loss of head, 18 lb.			Age.	
		Existing.	According to Age.	New Laid or Cleaned.	Present.	New Laid or Cleaned.	After Ten Years.	As per Coefficient.	Actual.
30-in.	1896	81.6	91.5	112	8.5	11.7	10.2	28	16
North 20-in.	1875	63.4	75.0	111	2.4	4.2	3.7	65	37
South 20-in.	1867	73.5	75.0	111	2.8	4.2	3.7	40	25–40
					13.7	20.1	17.6		

Note: Date of laying south 20-in. main is date original main was laid. Portions later relaid.

From the above it was seen that the coefficients (Column 3) for the 30-in. and the north 20-in. mains were unusually low, while the south 20-in. main was in about the condition that might have been expected. If these pipes were cleaned, it was estimated that the present system should be capable of delivering 20 million gal. per day to the city with the same loss of head that then existed (18 lb. at City Hall); and, if not cleaned, it appeared that under present conditions of demand the construction of a new main would be an immediate necessity.

Using the consumption figures from the Venturi meter record for June, 1912, the following estimate of future consumption was made: Average rate, 9.13 million gal. per day and maximum rate, 14.5 million gal per day, or 58 per cent. excess maximum to average rate. At an average annual rate of increase of 500 000 gal. per day, in five years the additional amount required would be 11.63 m.g.d. and 18.4 m.g.d. respectively for average and maximum drafts. Therefore, if the above assumptions are correct and if

the present system could be restored to its original capacity, it should be good for five years more, even with a rate of deterioration twice that usually assumed. (See totals in table above.)

If a new supply pipe were laid, it would be at least 36 in. in diameter and about 33 000 ft. long (about 6¼ miles). At a minimum price of $8.25 per linear foot, this line would cost about $270 000, the interest on which at 5 per cent. simple interest would be $13 500 per year, and at compound interest the charge would be $74 500 in five years.

The preliminary estimate for cleaning three miles of 30-in. and six miles of 20-in. was $15 300, a little more than the interest for one year on the amount necessary to lay a new 36-in. main. If, therefore, the construction of the latter main could be put off for five years without detriment to the service, the saving to the city was estimated to be about $60 000.

On account of the benefit which would result to the city if it were possible even partially to restore the carrying capacity of the existing mains by cleaning them, information was sought from various cities where the process had been applied. Very courteous and complete replies were received, and there seemed to be a unanimity of opinion that the work done was successful in operation and satisfactory in result. Some of the cities from which replies were received were:

City.	Sizes Cleaned. Inches.	Remarks.
Cincinnati, Ohio	6 to 16	Third contract for work.
Rochester, N. Y.	6 to 20	About 25 miles cleaned in all.
Newton, Mass.	24	
St. Louis, Mo.	15 and 20	
Brooklyn, N. Y.	6 to 36	
Atlanta, Ga.	30	
Am. W. W. & Guar. Co.	4 to 20	40 to 50 miles cleaned this season.

The list prices quoted by the National Water Main Cleaning Company of New York for doing work in the distribution system were:

PRICES PER LINEAR FOOT OF PIPE.

6-in.....16 cents	12-in.....22 cents	24-in.....40 cents
8-in.....17 cents	16-in.....26 cents	30-in.....65 cents
10-in.....18 cents	20-in.....30 cents	36-in.....80 cents

These were stated to be for average conditions for lengths of five miles or more given only for purposes of preliminary estimate, and were submitted with the reservation that local conditions might cause considerable variation either way. In Hartford a price of 28 cents per linear foor for 20-in. was given for a three-mile contract, with a further reduction if a greater length was cleaned. The conditions were exceedingly favorable for a large part of the way on account of few consumers on the line, advantageous location of gate valves and blow-offs for cutting out sections of proper length, and also because of a parallel main with cross-connections which gave ample water for operating the machine without interference with the city supply.

A contract was entered into September 4, 1912, with the National Water Main Cleaning Company to clean, on trial, three miles of 20-in. pipe, and if satisfactory results were obtained the cleaning process might be continued through several miles additional of 20-in. and three miles of 30-in. pipe.

Work was begun September 6 and suspended on October 24 on account of scarcity of water in the reservoirs. The results were very satisfactory, and during this period (forty-nine days) a total of 33 093 ft. (6¼ miles) was cleaned. On this section there were 154 service pipes which were shut off during cleaning, and only four were at all interfered with by the cleaning operations. Three of these were extension meters located at the street line with no curb cocks, and it was necessary to remove the meter and clean out the dirt. The other service affected was plugged but was easily relieved by a force pump. The following is a typical log of the operations:

October 15. Location, Farmington Avenue and Asylum Street, Sigourney Street to Ford Street. Distance, 2 747 linear ft.

During afternoon, 20-in. pipe exposed at Sigourney Street and at Union Place. Cleaning machine put into a 9-ft. piece of pipe and ready for insertion into the pipe line when cut was made.

8.30 P.M. Section, Gillette Street to Cathedral shut down.

9.40 P.M. Above section completely drained. Cutting began at this time at Sigourney Street.

FIG 1.

FIG. 2.
THE MACHINE USED IN CLEANING 20-INCH PIPE.

1.00 A.M. Section, Cathedral to Ford Street shut down.
2.00 A.M. Pipe cut out at Union Place and riser wedged into place.
2.33 A.M. Gate opened at Gillette Street to start machine.
2.50 A.M. Machine reached Union Place.
5.00 A.M. Machine having become wedged in riser, pipe was removed at this time.
6.25 A.M. Section closed in, joints made up, and water turned into section.

The usual force employed on this work was a superintendent, a foreman, a calker, fourteen laborers, and a double team for carting pipe materials and supplies.

Under average conditions 3 000 ft. was found to be the maximum effective length for cleaning. The contractor stated that 5 000 ft. had been successfully cleaned by him elsewhere, although in some places it had been possible to go only 1 500 ft. at a time, using water to drive the machine. If the machine were drawn through by a cable, the length of section is from 500 to 1 200 ft. It is stated that the machine can be operated by water under heads of as low as 10 or 12 lb. The least available head on the Hartford lines was somewhat greater than this.

The pipe machine used in cleaning the mains (Fig. 1) consists of three distinct sections attached to each other by a flexible joint in the connecting shaft which is central in all of the sections. These joints move readily and allow the machine to pass through ordinary water pipe curves if the radius is not too short. The first section consists of three spiders fastened to the shaft; these are armed with saw-tooth blades that project at right angles to the axis of the machine. The function of these blades is to cut up and tear loose incrustation and scale that adheres to the pipe walls.

The second section is made up of two spiders armed with smooth scrapers. The function of these blades is to scrape away all matter left clinging to the pipe by the first section.

Behind these two sections is a double piston fitting the pipe very closely, with leather gaskets pressed out by steel springs which are continuous around the entire circumference. The pistons are fitted with dampers which can be adjusted to the pressure of water and so regulate the quantity needed to wash ahead the scale and other matters cleaned from the pipe. Behind each spider, and loosely fitting on the center shaft, are

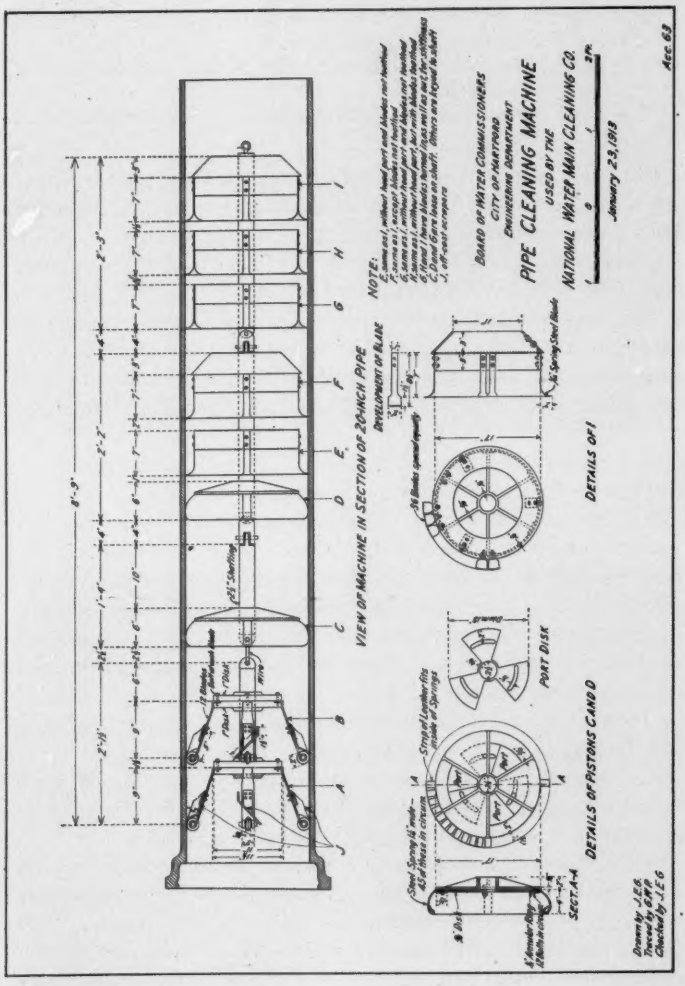

VIEW OF MACHINE IN SECTION OF 20INCH PIPE
ENVELOPMENT OF BLADE
NOTE:
BOARD OF WATER COMMISSIONERS
CITY OF HARTFORD
ENGINEERING DEPARTMENT
PIPE CLEANING MACHINE
USED BY THE
NATIONAL WATER MAIN CLEANING CO.
January 23, 1913
DETAILS OF 1
DETAILS OF PISTONS C AND D
PORT DISK
SECT. A-A
Acc 63

FIG. 1.

FIG. 1.

FIG. 2.
THE MACHINE USED IN CLEANING 20-INCH PIPE.

three somewhat flexible metal disks whose function it is to deflect the wash water towards the pipe walls and out through the cleaning blades, where the high velocity helps remove some matter and keeps the whole mass moving along with the machine.

Behind the pistons is another section which carries two rows of right and left off-cast scrapers. There are very heavy and are designed to smooth off the surface and leave a clean, smooth water way. These blades are allowed only just to touch the pipe walls, their position being kept by case-hardened rollers that run on the pipe wall. The gross diameter of the machine used on the 20-in. mains is 21½ in., the steel springs letting down at entrance and so keeping the machine firmly centered in the pipe. The steel blades are made especially for this purpose and are nearly all replaced after each draw. This replacement, of course, depends largely on the character of the incrustation, and when mud alone is found, the blades may require very little renewal.

Previous to the cleaning work a very thorough survey was made of the capacity of the pipe line by the use of the pitometer, and similar tests were made after the work was finished. A typical summary of the results of this work is given below.

Pipe cleaned: North 20-in. main, Farmington Avenue.
Section: Reservoir No. 1 to Vanderbilt Hill.
Length: First test, 16 400 ft. Second test, 14 650 feet.
Pipe laid in 1875. Age: Thirty-seven years. Kind: Cast iron.

	(1)		(2)
Date of test	August 22, 1912		October 2, 1912
Make of gage	Crosby		American
Unit of gage	1 lb.		1 ft.
Head lost, ft.	20 to 55		20 to 50
Range of velocity (ft. per sec.)	1.69 to 2.40		2.84 to 3.97
Possible error in coefficient	Per lb. 3%		Per ft. 1.5%
Mean coefficient; Chezy formula	69		111
Increase in capacity	—	61%	—
Average coefficient in Chezy formula	Weston (37 y.), 75		(New) 111
	Williams and Hazen (37 y.), 73		(New) 116

The loss of head was about the same in both cases, and sufficiently large so that an error of one pound or one foot would be comparatively negligible.

The north 20-in. main was cleaned from the reservoir to Union Place, a distance of about five miles. The south 20-in. main has been cleaned from the reservoir east about $1\frac{1}{4}$ miles. Tests of the flow made before and after cleaning indicated that in both pipes the carrying capacity had increased sufficiently to compare

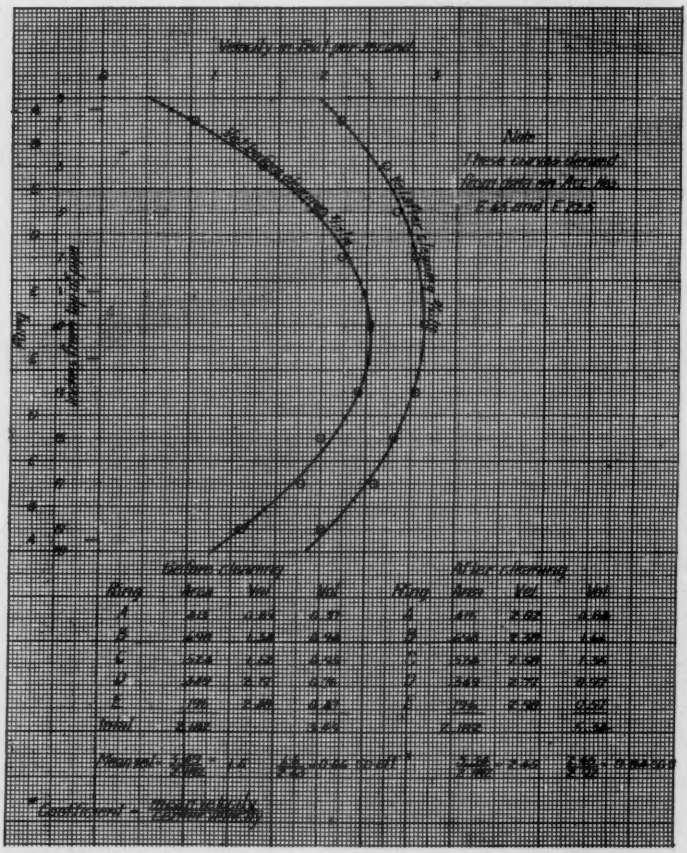


FIG. 2.
CURVES SHOWING THE EFFECT OF CLEANING UPON THE VELOCITY.

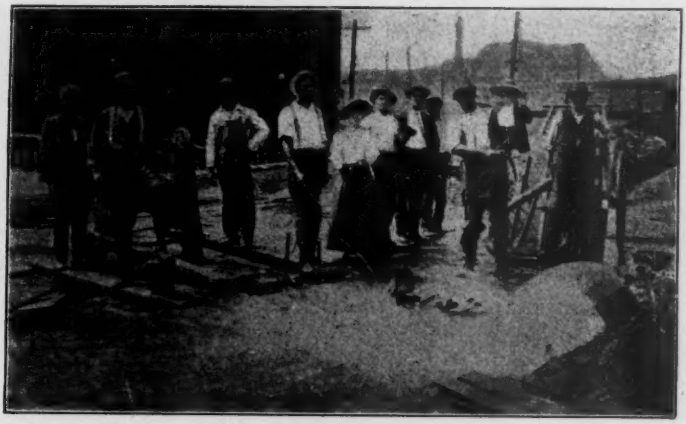
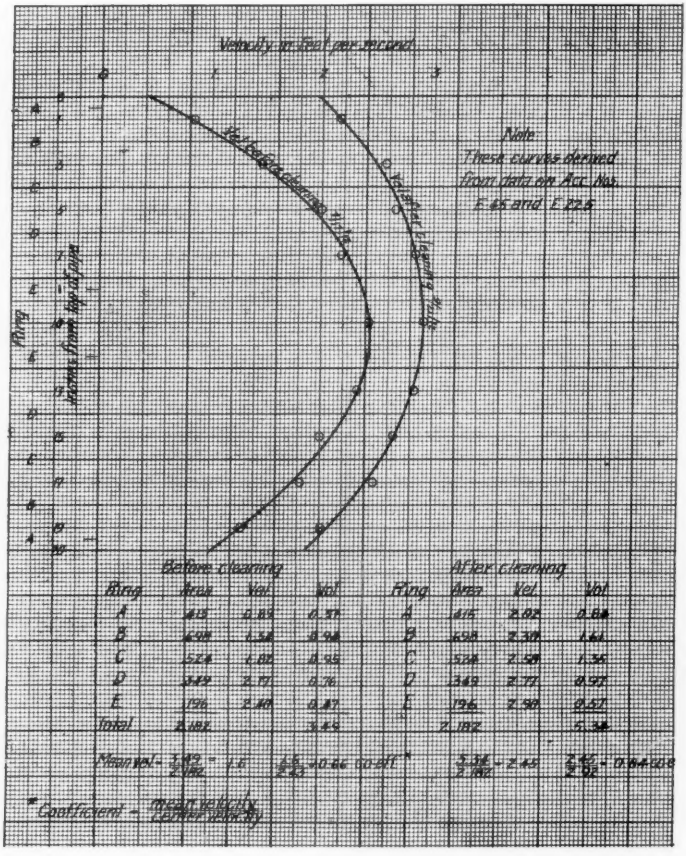


FIG. 1.
BEFORE CLEANING.

FIG. 2.
AFTER CLEANING.

[From the *Municipal Journal.*]

The north 20-in. main was cleaned from the reservoir to Union Place, a distance of about five miles. The south 20-in. main has been cleaned from the reservoir east about $1\frac{1}{4}$ miles. Tests of the flow made before and after cleaning indicated that in both pipes the carrying capacity had increased sufficiently to compare



Before cleaning				After cleaning			
Ring	Area	Vel.	Vol.	Ring	Area	Vel.	Vol.
A	.415	2.82	0.58	A	.415	2.92	2.84
B	.498	1.52	0.98	B	.498	2.38	1.46
C	.524	1.85	0.96	C	.524	2.58	1.36
D	.349	2.71	0.76	D	.349	2.71	0.97
E	.196	2.40	0.47	E	.196	2.90	0.57
Total	2.182		3.45		2.182		5.36

Mean vel. = $\frac{3.45}{2.182}$ = 1.6 $\frac{1.6}{2.23}$ = 0.66 co-eff.* $\frac{5.36}{2.182}$ = 2.45 $\frac{2.45}{3.82}$ = 0.64 co-eff.

*Coefficient = $\frac{\text{mean velocity}}{\text{center velocity}}$

FIG. 2.
CURVES SHOWING THE EFFECT OF CLEANING UPON THE VELOCITY.

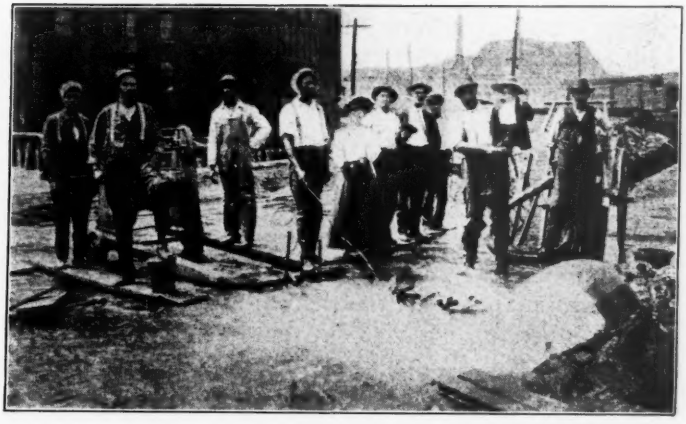


FIG. 1.
BEFORE CLEANING.

FIG. 2.
AFTER CLEANING.

[From the *Municipal Journal.*]

with Weston's tables for new 20-in. pipes. This is equivalent to a coefficient of 111 in the Chezy formula, the resulting increase in capacity being 61 per cent. and 50 per cent. respectively for the north and south 20-in. mains. Several readings of the amounts of water used during the cleaning were made from the records of the Venturi meter at the reservoir gate-house, and the following quantity is believed to be a reliable estimate of the amount per linear foot:

Quantity required to fill 1 ft. of 20-in. pipe	16.3 gal.
Quantity used in cleaning	24 gal.
Adding 25 per cent. for emergencies, etc.	9.7 gal.
Total estimated amount per linear foot	50.0 gal.

The total distance cleaned was 33 093 ft. ($6\frac{1}{4}$ miles), and it is estimated that 1 655 000 gal. of water were used. This amount is about one fifth of one day's supply to the city. Table 2 presents a summary of the work done and the results obtained:

A diagram (Fig. 2) is included for the purpose of showing the results of cleaning on the velocity. The references to "Ring," "Area," etc., are to the method and nomenclature given in the "Tables and Directions" of the Pitometer Company. In this connection it may be said that the incrustation removed was in places over an inch thick nearly around the pipe. Besides this, considerable quantities of pipe moss (Paludicella) were found near the reservoir end of the mains.

On account of a suggestion that the cleaning of water mains might have effect in causing or aggravating the so-called "red water" trouble, samples from the cleaned and uncleaned mains were sent to Mr. Jas. A. Newlands * with the request that especial attention be given in his examination to detecting any indications of "red water." The following extracts are given from Mr. Newland's reports on the samples submitted:

Report on Sample No. 1352 (sample taken October 1, 1912 from 20-in. main that has been cleaned):

"This sample, which I understand is taken from the clean main section, shows only very slight differences from Sample No. 1353

* Consulting chemist and bacteriologist, Middletown, Conn., and chemist of the Connecticut State Board of Health.

TABLE 2.

Location.	Date Tested.	Length, Feet.	Range of Flows, M.g.p.d.	Lost Head per 1 000 Ft.	Chezy Coefficient.
			Northerly 20-in. Main.		
Reservoir to LeMay's.					
Before cleaning	8/31/12	5 450	3.3 to 4.7	2.90 to 7.65	60 to 67
After cleaning	9/21/12	5 450	3.6 to 5.3	0.64 to 2.09	124 to 159
After cleaning	9/26/12	5 450	2.5 to 5.3	0.96 to 2.57	109 to 125
LeMay's to West Hartford Center.					
Before cleaning	9/14/12	4 430	2.8 to 4.2	3.80 to 7.00	50 to 56
After cleaning	9/26/12	3 750	3.6 to 5.2	1.70 to 2.90	94 to 115
West Hartford Center to Highland Street.					
Before cleaning	9/10/12	6 420	3.1 to 5.8	2.03 to 8.46	69 to 75
Vanderbilt Hill to Broad Street.					
Before cleaning	10/3/12	10 180	2.4 to 4.3	1.81 to 5.81	61 to 65
West Hartford Center to Vanderbilt Hill.					
After cleaning	10/2/12	5 450	4.0 to 5.6	1.18 to 3.63	102 to 128
Reservoir to Highland Street.					
Before cleaning	8/27/12	16 300	2.4 to 3.4	1.40 to 2.89	67 to 70
Reservoir to Vanderbilt Hill.					
After cleaning	10/2/12	14 650	4.0 to 5.6	1.55 to 3.01	110 to 112
			Southerly 20-in. Main.		
Reservoir to Highland Street.					
Before cleaning	8/27/12	16 300	2.58 to 3.91	1.52 to 3.35	73 to 75
Before cleaning	10/14/12	16 300	3.25 to 4.08	2.17 to 3.44	76.3 to 76.6
Reservoir to Westland Street.					
After cleaning	10/28/12	6 400	4.1 to 5.4	1.61 to 2.70	110 to 119

taken from the uncleaned main, and these differences are so slight as to be within the limits of laboratory error and the slight variation which might be expected in two samples from different points in the same pipe line. On a long line of cleaned pipe we might expect that, where the inner surface had been cleaned down to the

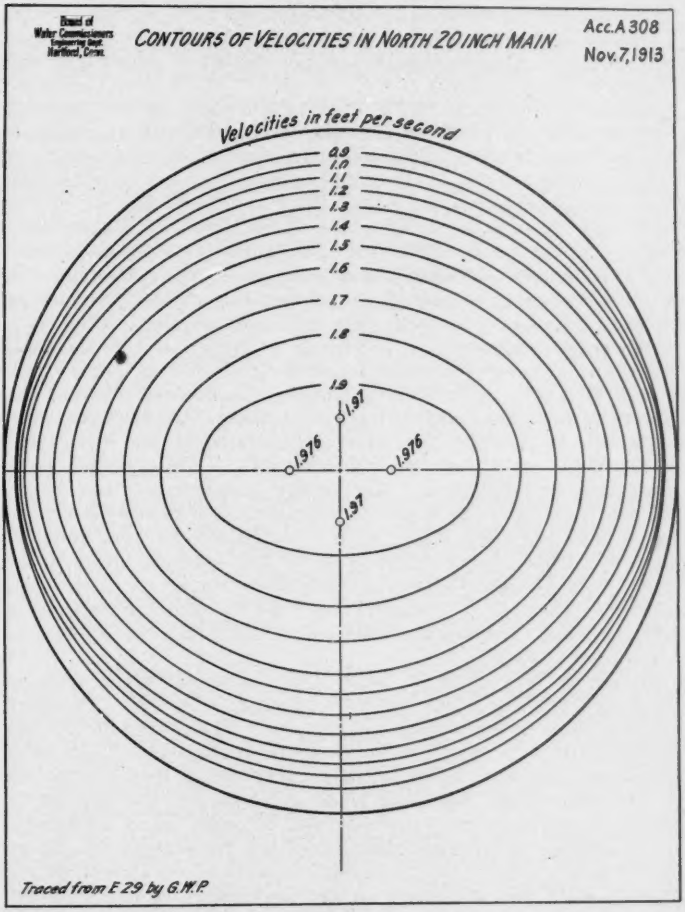


FIG. 3.

iron, at such points there would be some reductions of the oxide of iron by the action of decomposing algæ growths and other organic matter. This would result in iron being taken up by the water and a consequent increase in color. As the amount of dissolved oxygen in this water is probably high enough at all times to supply the oxygen required by the organic matter, there probably will be no appreciable effect on the color and iron content of the water. These samples show none, the color being the same in both cases, while the iron amounted to .3 part per million in this sample and .2 part in Sample 1353."

Letter of October 7, 1912: "With reference to the tap and hydrant samples, I will say that the results obtained do not show any appreciable effect of the cleaned main [on] the appearance or quality of the water. Under some conditions, as I have suggested, it is quite possible that for a time there might be some increase in color and iron matter content, due to the action of decomposing organic matter on the fresh iron with which it comes in contact, but the amount of organic matter in your reservoirs does not usually become great enough to exhaust the oxygen dissolved in the water, and I do not anticipate any material effect on the color of the water. However, it is difficult to determine how the various types of water will act under varying conditions, and I think it will be worth while to keep track of the relative colors of the waters in the cleaned and the uncleaned mains as the work goes on."

Report on Sample No. 1378 (taken October 28, 1912, from south 20-in. main that had been cleaned): "These results show practically no differences in the physical appearance of the chemical constituents of the water as compared with Sample No. 1370 taken from the north 20-in. main. No differences were noted in the color, turbidity, or sediment of the two samples, although we might expect slight differences even in two samples taken from different points in the same main. There is no indication at this time that cleaning the main has resulted in the beginning of 'red-water' trouble."

Letter of November 4, 1912: "I have looked the samples over carefully for evidence of 'red-water' trouble, but there appears to be no such effect at this time. The results on the two samples are more nearly alike than we usually find them, as it frequently happens that samples, although taken from two points on the same main, will show some differences in the amount of turbidity and sediment especially, due to unavoidable differences in the amount of sediment stirred up when the samples are taken. There is no evidence in these results, therefore, to show that the cleaned main has any effect on the appearance of the water at this time."

Some criticism of the work was made by a writer in one of the local newspapers that the cleaning of the pipes destroyed the inner coating, and the intimation was that the rusting of the mains would probably proceed very much more rapidly in the future than in the past. It has been stated by some engineers that the cleaning of cast-iron pipe frequently does increase the rate of tuberculation, and under some conditions that may be true. Previous to undertaking the Hartford work, inquiry was made concerning this matter of various water departments where the pipe had been cleaned. Very little information was obtained regarding the rate of returning incrustation, but regarding the removal of the coating, the opinion of all who had made examination was that the inside of the pipe was uninjured. Observations made on the ground showed no evidence of damage of this kind. The hardest test probably was encountered when the machine was pulled into the 9-ft. piece of pipe made ready for insertion in the line. In several cases this section was examined and no removal of the coating was apparent.

The following is a copy of the specifications under which the work was done.

SPECIFICATIONS.

The contractor shall clean and remove deposits and tubercular growth from all mains herein specified or any part thereof as directed by the chief engineer of the party of the second part, and in accord with the proposal on page 4, the location of said mains being shown in plans on file at the office of the said chief engineer, by its patented process and under the following specifications and terms:

The contractor shall provide the necessary tools, appliances, labor, and materials to perform and complete this work in an expeditious manner. The work to be done shall consist of excavating, cutting pipe to be cleaned, cleaning the pipe so as to remove rust, tubercles, organic growths, deposits, silt, and other foreign material due to the presence of water in the mains, reconecting the pipe, and refilling the holes.

The contractor shall make all necessary excavations for the execution of the work. The materials excavated from the openings thus made shall be placed in such a position as not to impede travel on the railroads, or unnecessarily impede the travel on the streets in which the openings are made.

The contractor shall take proper precautions to support and sustain the sewers, conduits, water and gas mains laid in or across the streets which may be liable to injury or damage from digging the openings herein mentioned, and have a sufficient quantity of timber and plank on the ground when necessary to use the same as required. All sheet plank and timber used during the progress of the work to support the sides shall be removed as the filling proceeds.

The contractor shall refill the openings and remove all surplus material. The openings thus made shall be filled with suitable material, put in horizontal layers not over six (6) inches thick, and each layer thoroughly rammed so as to render the whole filling solid and compact.

The contractor shall maintain at all openings made by them such guards and lights as may be necessary to prevent accident or injury to the person or property of others; and shall indemnify and save harmless the Water Department against any and all suits and actions brought against it, and from all damages, costs, and expense to which it may be put by reason of any negligence or carelessness in the performance of the work, or in guarding same, or by or on account of any act or omission of the contractor or its agents, except as herein specified and provided.

The Water Department shall furnish right-of-way and permits where same are necessary for breaking of pavements.

The Water Department shall notify all consumers in advance to shut-offs and shall assume all responsibility for such shut-offs, and save the contractor harmless from all damages, costs, and expenses incurred by reason of injury or damage to the person or property of another as a result of shut-offs.

On completion of the cleaning of each separate section the Water Department shall make immediate inquiry of each consumer as to any stoppage of flow in service pipes, and the Water Department shall immediately notify the contractor of any such stoppage, and the contractor shall at once remove any stoppage due to said cleaning operation. The house services shall have been shut-off at the curb or just inside the cellar wall, by the Water Department so far as possible, before the cleaning operation shall have been commenced, and should the Water Department fail to notify the contractor of any such stoppage within one week from the time the water is turned on to the section where such stoppage occurs, the contractor shall not be held responsible nor be required to repair same.

The Water Department shall not hold the contractor responsible for cutting pavements or excavations when due to incorrect maps or information as to the size and location of pipes, and the

contractor shall be reimbursed for extra labor entailed thereby, plus fifteen per cent. (15%) for contingencies.

The Water Department shall also reimburse the contractor for the actual cost and expense entailed in cutting pavements, making excavations, cutting and replacing mains to remove the cleaning equipment when same becomes necessary as a result of defective joints, surplus lead, bends, offsets, or special fittings which do not conform to the size of the main being cleaned, or are not shown on the plans.

The Water Department shall furnish one or more competent men to take charge of all shut-offs, and to promptly make such shut-offs when requested by the contractor or its representatives.

The contractor shall notify the Water Department when shut-offs are wanted.

The Water Department shall coöperate with the contractor, and assist in expediting the work of the contractor, by giving prompt shut-offs whenever requested by the contractor, and furnishing normal pressure in the mains and when necessary and possible to give higher pressure.

The contractor shall coöperate with the Water Department and assist them whenever possible to accommodate their consumers.

The Water Department shall not hold the contractor liable for any damages caused to its gates, valves, or hydrants by reason of their necessary operation in making shut-offs, or their operation under the direction of the Water Department.

The Water Department shall repave all openings for the cleaning and shall be responsible for such repaving.

The contractor shall make regular detailed statements of all overtime or extra materials which may be chargeable to the Water Department, giving the cost of materials and rate of pay of its employees plus fifteen per cent. (15%) for contingencies.

The contractor shall assume responsibilities for any claims made against the Water Department for any infringement of patents by the use of patented articles in the execution and completion of the work, and shall indemnify the Water Department for all costs, expenses, and damages which the Water Department shall be obliged to pay by reason of any infringement of patents used in said work.

Any damage done to the mains at joints where cuts shall have been made for the cleaning work shall be repaired and made fairly secure and tight by the contractor so as to be in first-class, serviceable condition at the completion of the work.

In reconstruction, the contractor will use such classes of pipe and special castings conforming to the New England Water Works Standard as may be designated by the chief engineer.

So far as possible, the work to be done nights and Sundays in order to avoid annoyance to consumers.

Plates XXXIII and XXXIV show views of the cleaning machine taken at different angles.

Diagrams 2 and 3 are given merely to show the velocity conditions existing inside the uncleaned pipes. Pitometer traverses were made on both the vertical and horizontal diameters of each. The north 20-in. main has been laid sixteen years.

Discussion.

Mr. Frank L. Fuller. I would like to ask how small a pipe it is feasible to clean in this way.

Mr. Saville. I cannot answer that. Our mains were all 20-in. in diameter.

Mr. Burt Bradley Hodgman.* There have been a great many 3-in. mains cleaned, but we do not pretend to clean anything smaller than that. Most of the work is on 6-in. and larger.

Mr. Miller. Where a city has only one main and no storage, or only storage enough for twenty-four hours, how will this thing work?

Mr. Saville. It took from half past eight at night to about half past six the next morning to clean our supply main, so that it was out of service for nine or ten hours.

Mr. Hodgman. We have cleaned the only force main in several cities, but I know of no place where the single force main cleaned was larger than 12-in. In cases of this sort we have a temporary make-up which we use to put the pipe in service. This temporary make-up can be put in in a very short time, and the water will pass through even when the machine is in the pipe, enough to give service in case of necessity. We have had only one experience where a fire broke out on the street where the main was being cleaned. That was on a 6-in. line in Warren, Pa. The main was cut in two places when the alarm was given, and eleven minutes thereafter there was pressure on the hydrants and no serious trouble resulted.

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*Civil Engineer, National Water Main Cleaning Company.

MR. FULLER. I should like to ask if it is necessary to shut off the main at the corporation cock or at the sidewalk?

MR. HODGMAN. In the house is as good as at the corporation.

MR. FULLER. The rust does not get into the service pipe?

MR. HODGMAN. Even if it were not shut off at all, if the fixtures in the house were perfectly dead, there would be no trouble with stoppage.

MR. EDWIN C. BROOKS. I will say that while I was at Cambridge we cleaned some 900 ft. of 6-in. pipe without taking any precautions about shutting off the supplies, or anything of the kind. The work was all done during the working day, and, although I had no means of determining what the increased flow was, still we found the discharge from the hydrants very perceptibly increased, and the job as a whole was very satisfactory.

MR. HODGMAN. We cleaned several miles of mains in Boston this spring, giving an increase of 210 per cent. on the 16-in. line on Brooks Street, East Boston, restoring the efficiency of that pipe to a coefficient of 139 by Williams and Hazen's formula. I would like to ask if Mr. Winslow can give some descriptions of our work.

MR. FREDERIC I. WINSLOW.* I did not have charge of the work just referred to by Mr. Hodgman, but in 1885 and 1886 we cleaned a few 4- and 6-in. mains in East Boston and South Boston. We found, in one case, that with a flow of 100 gal. per minute, the friction per 1 000 ft. of 6-in. pipe was 25 ft. before, and but 4 ft. after, cleaning. In another case with 83 gal. per minute, the observed friction before cleaning was 12 ft. per 1 000 and after the cleaning it was but 2.5 ft. This work was all done with a machine made by D. H. Sweeney, of Fitchburg, Mass., and consisted of a flexible central shaft, composed of solid steel springs connecting small castings, to which were hinged steel scrapers arranged radially around the shaft. There were coiled springs which kept the scrapers against the sides of the pipe and yet allowed the scrapers to turn back so as to pass taps or other obstructions. Rubber pistons, fitting the pipe closely, were attached to the shaft behind the scrapers, and the machine,

*Engineer of Extension, Water Service, Public Works Department, Boston, Mass.

placed inside the pipe, was forced through by water pressure. These pipes were thirty years old and originally uncoated.

A MEMBER. I would like to ask what happens to the corporation cocks when they happen to protrude through the pipe.

MR. HODGMAN. There have been a number of cases where that question has come up and special examinations have been made, and although in some places a slight mark would show on the very point of the corporation where the machine had passed it, no damage was done whatsoever.

MR. WILLIAM F. CODD.* We have had some 4- and 6-in. pipes cleaned by this company in Nantucket, Mass., with very good results. The first 4-in. main we had cleaned was 1 000 ft. long, and had been in use about thirty years, and it was about half full of rust and sediment, so that from a hydrant on the middle of the main we could get a stream which would just barely flow out of the opening. After the cleaning was done we could get a good fire stream, sufficient for use on a two-story house. We were very well satisfied that there was nothing at all left in the interior of the pipe after the work was done, and no services were filled up, and no damage was done to the corporation cocks or anything else that I could see.

A MEMBER. How small a pipe can be cleaned with pressure where you do not have to use a cable?

MR. HODGMAN. That depends a good deal on what is in the pipe. We have cleaned some 4-in. pipe with pressure, where they had 100 lb. or better. Ordinarily we consider that nothing under 12-in. can be cleaned with pressure.

MR. FULLER. May I inquire how this cable is introduced to pull the machine along?

MR. HODGMAN. First the main is cut in two places; the riser pipe is put in position at the end where we expect the machine to come out, and we put our temporary connection in at the other end, putting first the double carrier cup and a small cable attached. Turning the pressure through the temporary make-up, it drives this small cable through. That is tied to the large cable and the large cable pulled back with a windlass. Then the machine is attached to the heavy cable and pulled into the pipe, the pipe is

* Treasurer and Superintendent, Wannacomet Water Company, Nantucket, Mass.

made up permanently at that point, and the water turned on and the machine pulled through, flushing simultaneously. We don't use any other but man power, because you really have to feel your way through. We wouldn't guarantee the corporation cocks at all if we used any power except hand power, because once in a while a blade will catch temporarily on the corporation cock, and then it is just pulled over carefully, because all the blades are spring blades and they may not spring back, if the machine is going too fast.

In connection with the cut shown in Mr. Saville's paper of the 20-in. machine used on the Hartford work I think it would be of interest to the Association to note that this is only one of nine different types of machines which are used in various kinds of work. I submit herewith a picture of our turbine machine which is used under certain conditions. This machine is entered through a hatch

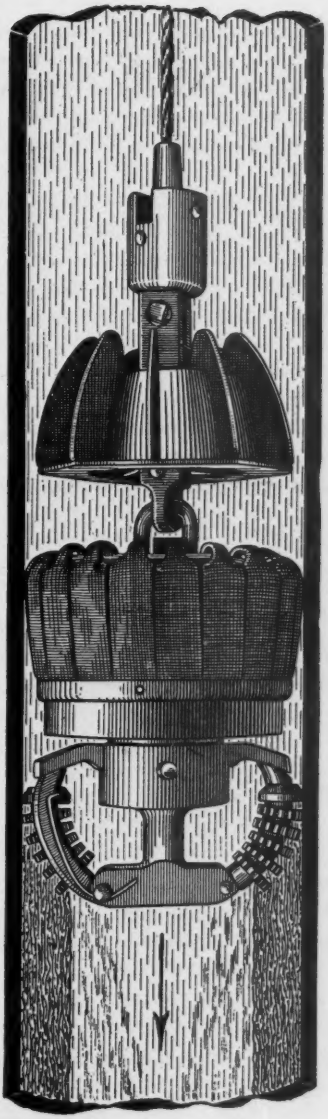

FIG. 4. A TURBINE CLEANING MACHINE.

box at one end of the line and is held back so that the cutting head is free to act upon the incrustation.

As has been noted heretofore, there are also other types of machines which are drawn by cable, and many different types of blades which are used on these various machines.

LOSS OF HEAD IN BENDS.

BY W. E. FULLER.

[*Read September 11, 1913.*]

There has been much disagreement as to the loss of head due to bends or curves in pipe lines. Many theories have been advanced as to the cause of this loss, and many attempts to determine the laws which govern it have been made. Experiments made with great care by different experimenters have resulted in quite different conclusions. It is not the purpose of this paper to advance any new theory, nor has the writer any additional experimental data to offer. It is the object of this paper to put the reliable data on the subject in a form which can be readily used in determining the probable loss of head in bends and curves under the conditions that are ordinarily met with in water-works practice.

It may be well to state briefly some of the causes of loss of head in bends and the reasons why experiments have not given results similar in all cases.

It is known that water passing around curves and bends loses a greater amount of head than when passing through an equal length of straight pipe. When the direction of the flow of water is changed, the distribution of velocity and pressures in the pipe is also changed, eddies are set up, and probably other actions take place which cause this excess loss.

It is more convenient, in comparing different bends, to divide the total loss of head due to the bend into two parts: First, that which occurs in an equal length of straight pipe; second, the excess loss due to the curve. If this is done it is necessary to assume that the effect of roughness of pipe, condition of joints, and other matters which affect the flow in straight pipe have the same effect on the flow in curved pipes. Quite probably this is not exactly true, in which case bends of the same dimensions with different hydraulic conditions would give different excess losses of head. The experimental data are insufficient to decide this matter, but they indicate that the effect of roughness, etc.,

is not greatly different in the two cases. Loss of head due to bends will be considered as that portion of the total loss in excess of the loss which would occur in an equal length of straight pipe.

It is known that the disturbance caused by the bend is continued for some distance in the straight pipe beyond the bend and that the loss due to the bend continues in this straight pipe. It is also probable that the pipe preceding the bend, causing more or less eddies, according to its condition, may affect the loss due to the bend. The fact that some of the loss due to the bend takes place in the straight pipe makes it necessary in experimental work to measure the head at some distance beyond the bend itself. The loss due to pipe friction must then be eliminated before the loss due to the bend can be obtained. This pipe friction represents a large proportion of the total loss, so that errors in obtaining it materially affect the loss due to the curve. With all these difficulties to overcome it is not surprising that the different experiments should not agree closely.

MAIN POINTS AT ISSUE.

For practical purposes it is essential to know the effect of both the radius of the bend and the velocity upon the loss of head for pipes of different sizes.

Until recent years Weisbach's formula, based upon experiments made on small pipes, was generally accepted. This formula is:

$$h_b \text{ (additional loss of head due to 90° bend)} = 0.13 + 1.85 \left(\frac{D}{2r}\right)^{\frac{3}{2}} \left(\frac{v^2}{2g}\right),$$

in which D is diameter of pipe, r the radius of the center line of the bend, and v the average velocity in the pipe. On this basis the greatest loss of head would be from a bend of the smallest radius, and the longer the radius the less the loss would be.

Experiments by Williams, Hubbell, and Fenkell* at Detroit on pipes of 12, 16, and 30 in. in diameter, indicated losses quite different from those given by the Weisbach formula. From

* "Experiments at Detroit, Mich., on the Effect of Curvature upon the Flow of Water in Pipes," by Gardner S. Williams, M. Am. Soc. C. E.; Clarence W. Hubbell, M. Am. Soc. C. E., and George H. Fenkell, M. Am. Soc. C. E. Transactions Am. Soc. C. E., vol. 47. 30-in. pipe data, pp. 185 and 360; 16-in. pipe data, pp. 159 and 185; 12-in. pipe data, pp. 181 and 185.

these experiments it was concluded that the loss of head was a minimum for bends with radii of about two and one-half times the diameter of the pipe. These experiments also indicated that the loss did not in all cases vary as the square of the velocity.

Further experiments made by Schoder * at Cornell on 6-in. pipe, Davis† at the University of Wisconsin on 2-in. pipe, Brightmore ‡ in England on 3-in. and 4-in. pipe, and others, showed that the Weisbach formula did not hold for larger pipes under ordinary conditions of service. These later experiments, however, did not confirm the Detroit experiments as to the minimum loss occurring with bends of a radius of $2\frac{1}{2}$ pipe diameters. These different experiments indicated quite different variations of loss in relation to the velocity. Some of the experiments showed this relation as high as $v^{2.75}$, while others showed it as low as $v^{1.5}$.

These experiments give the best basis that we have of obtaining the loss of head in bends.

The experiments were all carefully made, every effort being made to eliminate errors. The conditions existing for the different experiments were near enough alike to justify the expectation of at least an approximate agreement.

In the discussion of the question resulting from these experiments it seems to have been assumed that the loss of head in bends on different sizes of pipe should be the same when the radius of the bend in terms of the diameter of the pipe were alike. The writer sees no valid reason why this should be so. With so many different factors contributing to the loss there seems no reason to assume such a relation. If this assumption is abandoned, a much closer agreement between the data can be obtained and it seems better to accept the experiments as they stand, adjusting the conclusions to the data rather than to assume that some of the data are in error simply because they do not satisfy the above assumption.

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* "Curve Resistance in Water Pipes," by Ernest W. Schoder, Assoc. M., Am. Soc. C. E. Transactions M. Am. Soc. C. E., vol. 62.

† Discussion of "Curve Resistance in Water Pipes," by George J. Davis, Jr., Assoc. M., Am. Soc. C. E. Transactions Am. Soc. C. E., vol. 62, page 103.

‡ "Loss of Pressure in Water Flowing through Straight and Curved Pipes," by A. W. Brightmore, M. Inst. C. E. Minutes of Proceedings Inst. C. E., vol. 169, p. 323.

EFFECT OF THE RADIUS.

A study of the data shows that the loss is more nearly the same for different sizes of pipes with bends of the same actual radius in feet than for bends of the same radius in pipe diameters. This is shown by a comparison of Figures 1 and 2.

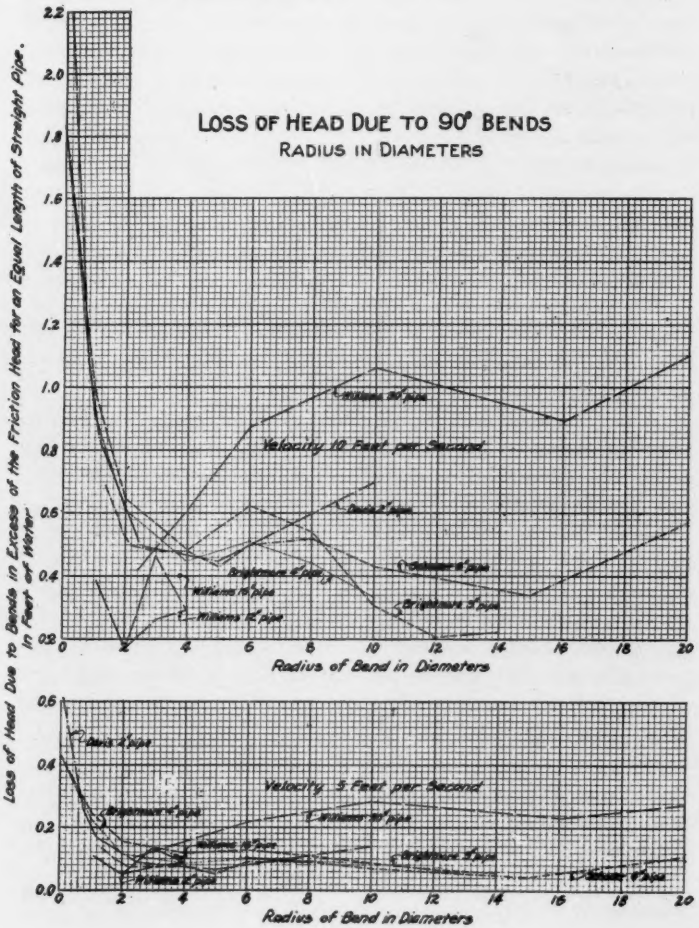
LOSS OF HEAD DUE TO 90° BENDS
RADIUS IN DIAMETERS
Loss of Head Due to Bends in Excess of the Friction Head for an Equal Length of Straight Pipe. in Feet of Water
Velocity 10 Feet per Second
Velocity 5 Feet per Second
Radius of Bend in Diameters
Radius of Bend in Diameters

FIG. 1.

Fig. 1 shows a plotting of the data on the basis of the radius in pipe diameters, while Fig. 2 shows a similar plotting on the basis of the radius in feet. On Fig. 1, while the curves representing the losses in bends of diameters from 2 in. to 6 in. agree fairly

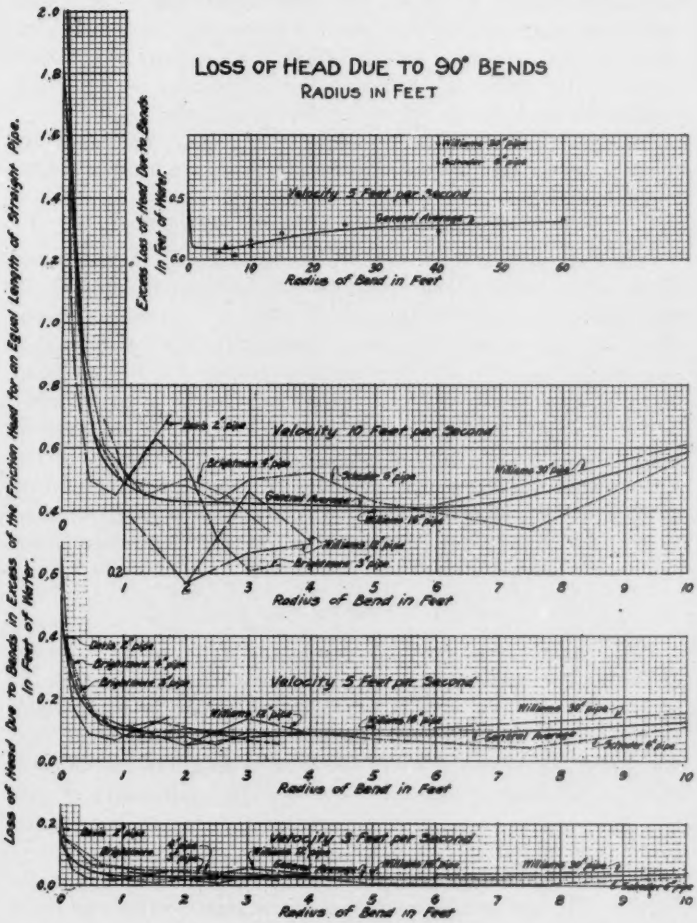
LOSS OF HEAD DUE TO 90° BENDS
RADIUS IN FEET
Loss of Head Due to Bends in Excess of the Friction Head for an Equal Length of Straight Pipe. In Feet of Water.
Excess Loss of Head Due to Bends In Feet of Water.
Velocity 5 Feet per Second
Velocity 10 Feet per Second
Velocity 5 Feet per Second
Velocity 3 Feet per Second
General Average
Radius of Bend in Feet

FIG. 2.

closely, those for the larger pipes are very different. On Fig. 2 a much closer agreement between the small and large pipe curves is obtained.

It is probable that neither of these diagrams is on the correct basis, and that the actual relation between the loss of head and the radius is a more involved one. Possibly the inner radius or the outer radius of the bend should be used for the comparison instead of the radius of the center line; or it may be that both r and D are involved in some more complicated form.

On Fig. 2 the average curves drawn fit the data approximately, and may be used for obtaining the probable loss of head in bends.

RELATION OF LOSS OF HEAD TO VELOCITY.

Values of the loss of head for different velocities due to bends of the same radius, taken from the average curves on Fig. 2, were plotted on logarithmic paper in relation to velocity. From these plottings the relation was established that the loss of head is proportional to $v^{2.25}$. On this basis a formula for loss of head may be stated as $h_b = kv^{2.25}$, in which k is a coefficient different for bends of different radii, and h_b is the loss of head in excess of the loss in a straight pipe of a length equal to the length of the curve. On Fig. 3 is given the values of k for bends of radii up to 60 ft. This relation between h_b and v is an average relation, as indicated by the experiments used. Further experiments may change it materially.

PRACTICAL USE OF THE DATA.

Fig. 2 gives the loss of head due to 90 degree bends in excess of the loss due to friction in straight pipe of a length equal to the length of the curve. To compare the total loss of head which would actually occur in pipe lines containing these curves, it is necessary to take into account the relative length of the different curves. The use of long curves makes the total length of pipe less than the use of short curves giving a corresponding smaller loss in pipe friction.

The introduction of this matter brings in a difficulty in that the friction will vary as the roughness of the pipe, so that the curve giving the least total resistance for one pipe will not do so for an-

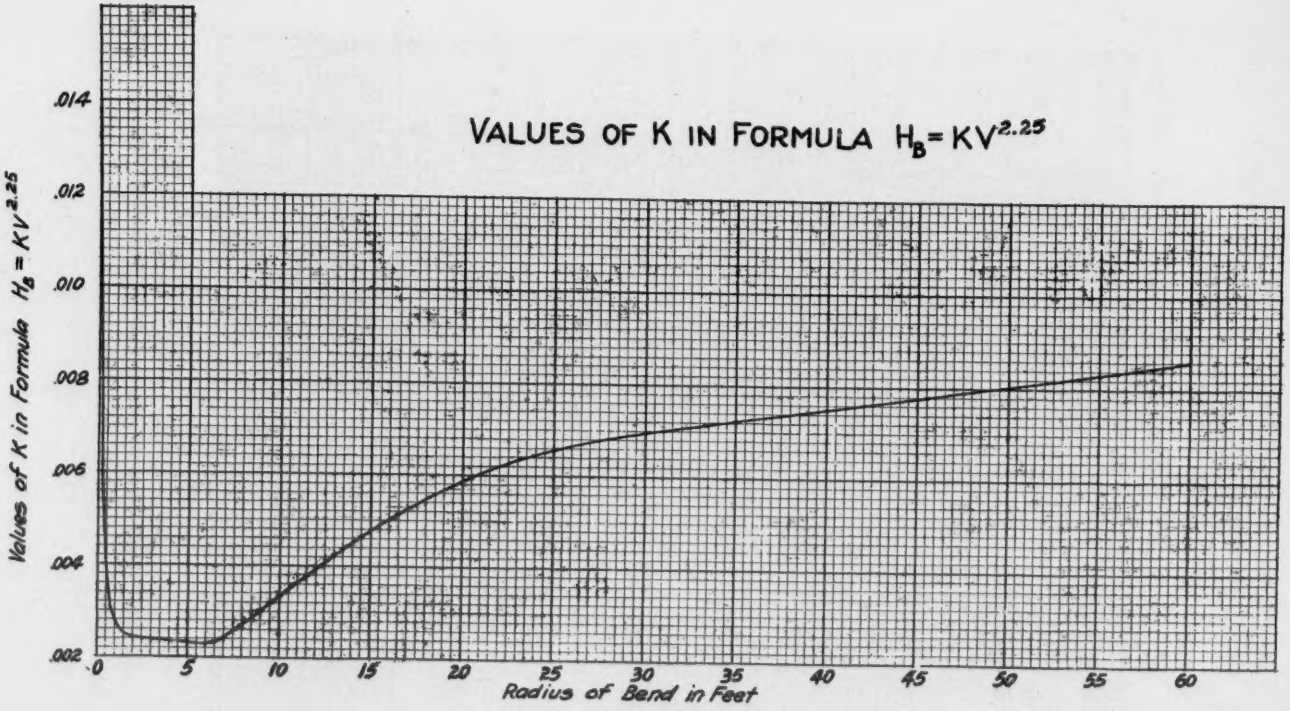
VALUES OF K IN FORMULA $H_B = KV^{2.25}$
Values of K in Formula $H_B = KV^{2.25}$
.014
.012
.010
.008
.006
.004
.002
0
5
10
15
20
25
30
35
40
45
50
55
60
Radius of Bend in Feet

FIG. 3.

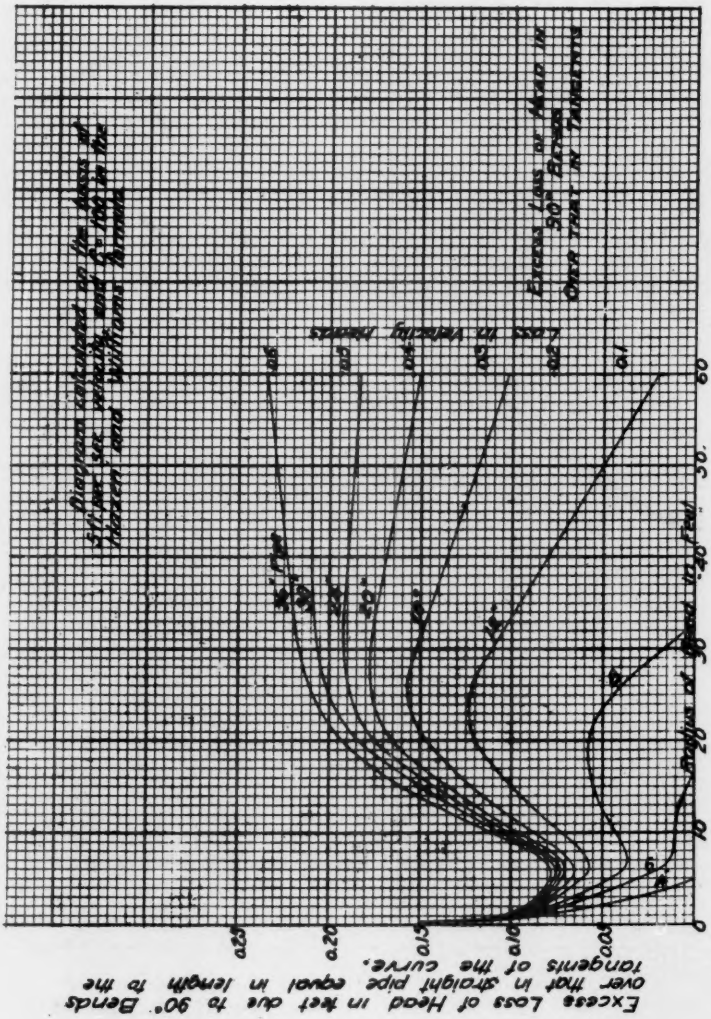
Diagram calculated on the basis of 3/4 inch pipe, velocity 10 feet per second, and 90° bends of various radii.
Excess Loss of Head in 90° Bends over that in Tangents
Loss in Vertical Pipes
Radius of Bend in Feet
0
10
20
30
40
50
60
0.05
0.10
0.15
0.20
0.25
Excess Loss of Head in feet due to 90° Bends over that in straight pipe equal in length to the tangents of the curve.

Fig. 4.

other pipe with different hydraulic conditions. It is most convenient to compute the loss of head in pipe lines by taking the actual lengths of the tangents as straight pipe, finding the frictional resistance in it, and then adding the excess resistance due to curves and other specials.

To meet this requirement Fig. 4 has been drawn, on which is shown the excess loss of head in bends over what would occur in straight pipe of a length equal to the tangents of the curve under average conditions. The data for plotting this diagram were obtained as follows: The loss due to the curve is taken from the average curve in Fig. 2. The friction in straight pipe of a length equal to the difference between the length of the tangents and the length of the curve is then deducted. The frictional resistance in straight pipe is taken according to the Hazen-Williams formula with $c=100$. This coefficient represents the average pipe after it has been in use for some years. As the loss of head in bends becomes of most importance at the time when the pipe is being used at its maximum capacity, which usually comes after some years of use, this value of c will probably meet the usual requirements. For new pipe well laid this excess loss in head would be somewhat greater, while for pipe in very bad condition it would be less.

Fig. 4 shows the following interesting points:

1. The excess loss of head in bends is greater for large pipes than for small ones.

2. For large pipes a six-foot radius bend gives the least resistance, unless very long radii are used.

3. If the radius can be made very long, the least resistance will evidently be from the bend of greatest radius.

4. For small pipes, at least, with long radii the loss of head will be less than it would be in straight pipe of a length equal to the tangents of the curve. This occurs when the saving in friction head due to shorter line becomes greater than the excess loss due to the bend.

NEW ENGLAND WATER WORKS ASSOCIATION STANDARD BENDS.

In order to show the loss of head for bends in ordinary use, Table 1 has been prepared on the same basis as Fig. 4, giving

the excess loss for bends made according to the New England Water Works Association standard.

TABLE I.

LOSS OF HEAD DUE TO NINETY DEGREE BENDS OF THE NEW ENGLAND WATER WORKS ASSOCIATION STANDARD.

Size of Pipe. Inches.	Radius Bend. Feet.	Excess Loss over Loss in Straight Pipe of Length Equal to Tangents. v=3 ft.	v=5 ft.	v=10 ft.
4	1.33	0.021	0.073	0.37
6	1.33	0.025	0.082	0.40
8	1.33	0.026	0.086	0.41
10	1.33	0.027	0.089	0.42
12	1.33	0.028	0.090	0.43
16	2.0	0.026	0.085	0.41
20	2.0	0.027	0.086	0.41
24	2.5	0.026	0.085	0.41
30	3.0	0.026	0.083	0.41
36	4.0	0.026	0.083	0.40

NECESSITY FOR CONSIDERING LOSS IN BENDS.

For most lines of small pipe, consideration of economy or convenience in laying will govern the selection of the bend or curve to use. Generally, of course, the use of very sharp bends should be avoided. In designing pipe systems about pumping stations, filter plants, and elsewhere, where many specials are necessary, a thorough understanding of the loss is important to avoid unnecessary loss of head.

For large pipes the losses in bends assume a far greater importance. The loss is more important for several reasons. First, the actual loss is greater for the larger pipes than for small pipes. Second, for the same velocity the frictional loss is less for large pipe than for small pipe, so that the loss in bends is a greater proportion of the total loss. Third, the amount of money involved is greater in the case of large pipe, and a greater expenditure is justified to avoid losses of head.

The importance of losses of head which occur on large pipe lines at bends and at other specials and at entrances and outlets of the pipe to structures is not as generally realized as it should be.

It is not uncommon to find losses from such causes, in large and comparatively short pipe lines, a large percentage of the total loss. In many cases much greater capacity of the line could have been obtained by proper consideration of the losses in the design of these works, and in some cases the capacity could have been nearly if not quite doubled. Instances of this may be found in intake and suction pipes. The importance of these losses may be understood when it is realized that in 1 000 ft. of 72-in. pipe a single 90 degree bend poorly designed may readily reduce the capacity of the line by 5 per cent., and a poorly designed inlet or outlet of the pipe to a structure may reduce the capacity by fully 10 per cent. It is not uncommon to find structures on pipe lines in which the velocity is suddenly reduced to a small amount, after which it is again increased. Such structures are extremely wasteful in head. A careful design to secure gradual changes in velocity and to prevent eddies at specials is very essential in order to secure the proper capacity of large lines and to prevent the waste of capital in building larger pipe lines than are needed.

LOSS OF HEAD IN OTHER THAN NINETY DEGREE BENDS.

There are but little data on losses in curves of radii other than 90 degree curves. Even with bends of small curvature the flow is disturbed, eddies are started, and considerable loss of head may result. It seems certain that the loss in 45 degree bends is greater than one half that in 90 degree bends. Until more information is obtained, the writer suggests the use of the following values for losses of head:

For loss of head due to 45 degree bends, use three fourths that due to 90 degree bends of the same radius.

For loss of head due to 22.5 degree bends, use one half that due to 90 degree bends of the same radius.

For loss of head due to a Y-branch, use three fourths that due to a tee.

APPROXIMATE RULES FOR LOSSES OF HEAD.

The loss of head in bends, for ordinary velocities, that is, from 3 to 6 ft., is approximately proportional to the velocity head $\left(\frac{v^2}{2g}\right)$.

It is convenient to express the loss in this way, and for rough approximations the following rules will serve.

For 90 degree bends of a radius in excess of 1.5 ft. and less than 10 ft., $h_b = \frac{1}{4}\left(\frac{v^2}{2g}\right)$.

For tees (bends of zero radii), $h_b = 1\frac{1}{4}\left(\frac{v^2}{2g}\right)$.

For sharp 90 degree bends of 6-in. radii, $h_b = \frac{1}{2}\left(\frac{v^2}{2g}\right)$.

Only further experimental work can satisfactorily settle some points involved in the loss of head in bends. Experiments which would add to the data on the loss of head in bends of large diameter would prove of the greatest service. It is for such bends that the matter is of the greater importance and the data more limited.

DISCUSSION.

MR. FRANCIS T. KEMBLE. Mr. President, I would like to ask Mr. Fuller whether his experiments cover differences of speed. With a railway curve it is considered that different curves have different speeds; you will run round a given radius with less friction at 30 miles an hour than you will at 40 or 50 miles an hour.

MR. FULLER. The data indicate that the radius of the bend of least resistance for one velocity would not be the same as that for another velocity. This difference, however, is slight, and the data which we have are probably not sufficient for such refinement. Fig. 3 gives the value of K in the formula $H_b = KV^{2.25}$. By the use of this formula the loss of head for any velocity may be obtained.

MR. ALLEN HAZEN. Mr. President, this is certainly a most important subject. I think the matter of extra loss of head in bends and special structures and entrances is one which baffles engineers and those who make hydraulic calculations more often than any other. More disappointment in the expected capacity of pipes has come from inadequate allowances of this kind than from any other single cause. I have known repeatedly of cases where pipes have been installed to deliver certain quantities of

water, and have failed to come up to expectations because adequate allowances were not made for these extra losses. Mr. Fuller's study bears out the general idea which we have had for many years, that a fair allowance for ordinary bends in water-works practice is about a quarter of a velocity head; but it shows that we shall have to be more careful in applying this rule to see that the curves come within the limits to which it applies.

Mr. Richard Winslow Sherman. In view of the well-known fact that friction is largely caused by the confusion of the particles of water in flowing through a pipe, this confusion being much increased in passing round bends, this increase, according to the author, having some relation to the length of the bend, would it be a fact that in a 24-in. pipe making a right angle bend with a radius of 5 ft., the loss of head by friction would be less than if the same bend were made with a radius of 15 ft., by reason of the confusion of the particles of water in the pipe occurring throughout a greater length of bend, say, three times as much length with a 15-ft. radius as with a 5-ft. radius? Would that be the case, would the loss be less in the shorter bend?

Mr. Fuller. For the 24-in. pipe there will be more total loss of head in a pipe line with the use of a 15-ft. radius bend than with a 5-ft. radius bend. With 6-in. pipe or smaller this would not be true; and with the 24-in. pipe, if the radius were made very long, perhaps several hundred feet, the loss would be less than with a 5-ft. radius.

ADVISABILITY OF SECURING LEGISLATION FOR MAKING WATER BILLS A LIEN UPON PROPERTY SUPPLIED.

TOPICAL DISCUSSION.

[*November 12, 1913.*]

MR. ROBERT J. THOMAS.* In regard to making water bills a lien on property, some years ago, as president of the New England Water Works Association, I signed a petition to the Massachusetts legislature to have a law to that effect enacted, and with a number of other water-works men of Massachusetts appeared before, I believe, the Committee on Cities and advocated a law to that effect. The city of Boston was represented by its water commissioner and by its attorney, and several other cities were represented.

There was no question about the arguments being to the point, and there was no question but that we were successful in presenting clearly to the committee that such a law should be enacted; that under the present conditions several water-works departments had lost thousands of dollars each year, because of the fact that they were unable to collect the water bills on property that had been transferred from one owner to another.

In the years when water bills were based upon fixtures, and were rendered a year in advance, it was an easy matter if a bill wasn't paid within a month or two to shut off the water or to collect the bill before the water was shut off. But when meters came into use, and it became necessary to have the water supplied for three months or four months before a bill could be rendered, then a city or town was liable to lose the water bills for those three or four months before the water could be shut off, as the bills were not rendered until a month after a quarter during which water had been supplied. So that the advent of meters made it necessary that some law should be passed to enable water departments to collect the money due them for the three months previous.

* Superintendent of Water Works, Lowell, Mass.

The city of Boston, if I remember rightly, their commissioner stated, had lost something like thirty thousand dollars a year from delinquent water takers. The city of Worcester had lost several thousand dollars a year from the failure to collect water bills, owing to change in the ownership of property. A law was passed in 1898 which prevented any water department from shutting off the water due to a bill contracted by a previous owner. That caused a hardship to the water departments, and prevented them from collecting many bills that were due.

To any person familiar with the subject, or any disinterested party listening at the hearing before the committee, there could not have been any doubt that the case had been presented successfully, and that the committee ought to have reported a law making water bills a lien on property. There was no opposition, no remonstrance whatever. No member of the committee disputed any argument that was made there, nor any assertion. In consequence we naturally thought that an act would be passed in accordance with our petition.

Shortly after the hearing before the committee, I met what is called a " legislative agent " in the lobby of the State House, and talked the matter over with him. I told him that there had been no opposition to the measure and that we were very hopeful of getting it through. He looked very surprised to think that I was so simple-minded as to expect that a bill like that would go through, notwithstanding the fact that there was no opposition. " Why," he said, " there won't be a member of that committee who will favor the bill." I said, " There was no opposition to it at all." He replied, " They don't have to go to meetings of the committee to oppose anything of this kind; it will be done quietly, and the committee will report against the bill." And they did, and the bill failed of passage. Although there was a strenuous fight made on the floor of the House, a majority voted to accept the report of the committee.

I understand the point they made was that it was up to the cities to collect their own bills by shutting off the water, to look after their bills more closely, not to allow the bills to be outstanding so long, and that within thirty days, anyway, of the time a bill was rendered the water should be shut off or the bill paid, and if it

wasn't it was the fault of the water department or the city or the collectors of the water bills in the different cities, and we had no business to come to the legislature and expect any assistance from them. I have considerable doubt as to whether any other attempt would be successful in getting such a bill through. Of course there is nothing like trying.

MR. A. R. HATHAWAY.* If the "lobby argument" was sufficient to block such legislation in enlightened Massachusetts I would like to ask, what was the argument successfully used in New York State, in the state of Connecticut, and in other states we might mention, which have had such a lien law for a number of years, and what was the argument so successfully used in San Diego, Cal., which has put in a large water system recently and has adopted new and up-to-date ordinances, rules, and regulations, among them being the following very drastic lien-law?

ABSTRACT FROM NEW ORDINANCES GOVERNING WATER WORKS AT SAN DIEGO, CAL.†

"Penalties for Delinquents.

"Should an account not be paid within ten days after coming due, a penalty of 10 per cent. shall be added to the bill, and if the total amount then due is not paid within ten days after the adding of the penalty, the said account and penalty shall be deemed delinquent and an additional penalty of 50 cents shall be added, and the superintendent of the Department of Water may cause the water to be shut off from the premises from which the account is delinquent, and the water shall not again be turned on until all arrearages and charges shall have been paid."

"Rates Lien against Property.

"In addition to any other remedy provided herein for the enforcement and collection of any water rate, charge, or account, all rates provided for in this ordinance shall be charged against the property on which it is furnished, and against the owner thereof, and shall be a lien against the premises to which any water may be supplied, and a charge against the owner thereof and the occupant thereof using the water, and if for any cause any sums owing therefor become delinquent, the water shall be shut off, and in no case shall it be turned on to the same property until all such delinquencies shall have been paid in full and such property

* Water Registrar, Springfield, Mass.

† Copied from *Engineering News*, September 4, 1913.

owner and occupant shall be severally responsible to the city in an action waged by the city in any court of competent jurisdiction for the amount of all such rates as may be due and unpaid, together with all penalties provided herein and costs. No change of ownership or occupation shall affect the application of this section."

I am deeply interested in this question, and I wish there could be a water lien-law passed which would help us in collecting our bills for metered supplies. I believe that the amount of money any city loses is not the main argument, — I know in Springfield we collect very closely, — but there is a growing tendency among new owners of property to avoid payment of water bills left against the property acquired. I believe that this Association ought to look into this matter more than it has, and, perhaps, stand by another movement for a lien-law.

Mr. George A. King.* Last winter Mayor Fitzgerald petitioned the legislature for an act of this kind, and the corporation counsel, Judge Corbett, appeared in the interest of the city of Boston and advocated before the Committee on Judiciary the enactment of such a law. I was there, and as there was no one there to object, I used the name of the New England Water Works Association and the water departments of Massachusetts as freely as I could. There was no opposition at the meeting, no one spoke against the proposition; there were two in favor and no one against. The committee reported reference to the next General Court.

I think the opposition comes from the real estate men. They object to having an additional burden put upon conveyancing, and they employ the legislative agents. I would like to ask Mr. Ballou of Woonsocket how the law which was enacted in Rhode Island some five years ago is working.

Mr. Arthur F. Ballou.† There is a law in Rhode Island that a water bill is a lien on property. If the ownership changes and there is an unpaid water bill, we shut off the water, and if the new owner wants water the only way he can get it is by paying the bill. We don't have any unpaid bills. But the law has never been tested, and I think that if anybody with

* Superintendent Water Works, Taunton, Mass.
† Superintendent, Water Works, Woonsocket, Mass.

sufficient financial backing were to take the matter into court he would win. The law works all right however, so long as it is uncontested, so we are quite content with it as it stands.

Mr. Lewis M. Bancroft.* The gentleman says that the water remains shut off until the new owner asks to have it turned on; but how does the department find out that the property has been sold? I know that in our town many times property is sold and, perhaps, it is several months before we find out who the new owner is. I had one experience which was rather amusing. I telephoned to the man who was the former owner of the property and asked him who the new purchaser was, and he replied, "It is up to you to find out."

I have attended several hearings at the State House before the Judiciary Committee and the Committee on Cities, of which Mr. Thomas has spoken, and one objection which I heard raised at one of the hearings was made by a conveyancer, who made the claim that it would make one more thing for him to look up, and would cause him a little trouble.

Mr. Hathaway. I have heard that objection also, but at home I have talked with several of our leading lawyers, among them one who is perhaps one of the leading conveyancers in the state, and he has always maintained that there is no legal objection, and no vital objection, that he could see, to making water bills a lien on the property. I have talked with real estate men, and you know how they can raise objections from their own point of view. They don't want the bother of going to the place of record, or of including the water bill in their transactions, in the dickering about a piece of real estate; but it can, of course, be done, and theirs are simply selfish objections, when you simmer them down. I was speaking only yesterday with our city collector, and he was emphatic in saying the water bills ought to be a lien on the premises, so that cities and towns should be assured of their revenue. It seems to me that the principle of the thing is right, and I can't see any good objection to it. I was talking with a real estate man day before yesterday, — a man who has acquired considerable real estate under foreclosure and by watching for bargains — and one who would naturally be expected to make

* Superintendent Water Works, Reading, Mass.

objection to having the water bill a lien on the property, — and he said: "Of course it will make another thing to take into account. When I buy a piece of property under foreclosure I expect to pay the insurance, the taxes, and other municipal assessments, and if the water bill was a lien on the property I should expect to pay that also. But after all," he said, "I really can have no vital objection, as in the end it all comes out of the tenants."

MR. FRANK L. FULLER.* It seems to me that if we make the owner responsible for the water bill the tenant will have no incentive to use a moderate amount. If the tenant intends to go out and not pay his water bill, he cares nothing about how much water he uses. In such places, where the landlord pays the water rate, the tenant has no pecuniary incentive to use only a reasonable amount. It seems to me, looking at the matter from this standpoint, that the proposed lien-law is not a good one. I don't know how it is in large cities, but in a town like Wellesley we have comparatively little trouble in collecting our water bills from tenants. There are a great many tenants, and the water is charged directly to them, and we lose very little money from them.

An advance charge should always be made to cover loss from a shifting population.

MR. JOHN O. HALL.† This is a question of a great deal of importance, and it has many phases. As I understand the situation at the present time, the bill has been referred to the next General Court. Now, I would suggest two things: First, that the committee having this matter in charge see that the bill is resurrected and put in the calendar in January for action; and, second, that the present committee, or a subcommittee, appear before the Massachusetts Real Estate Exchange and advocate the matter in its various phases before them, and get a number of them, as you undoubtedly can, to join with you in following up the bill and securing its passage. Then, when the bill has come before the legislative committee, the members of the Association should follow it up by conferring with their Representatives and Senators and securing the influence which they have on the floor of the Senate and House, in order to accomplish

* Civil Engineer, Boston, Mass.
† Quincy, Mass.

the desired result. That has been my experience and my method of procedure in various matters in which I have been interested in the legislature of Massachusetts. It seems to me that persistent work of that kind will finally result in securing what we all so earnestly desire.

MR. FRANK A. MCINNES.* I will say that the corporation counsel of Boston proposes to again try to secure the passage of such a law. He requests, and would very greatly appreciate, the coöperation of the Association.

I think the last speaker has put the matter exactly right; we must meet our opponents in their own way. We must get the real estate men; they will not object, the best of them at least, and the lawyers, I think, will generally support us, as the legislation we desire is a necessity in the larger cities at least. Perhaps the gentleman from Wellesley does not need it as acutely as we do. Within a few years, we will have in Boston 100 000 meters; our bills are rendered quarterly, and it is fully two months after the bill issues, as our machinery operates, — we hope to expedite it, — before we can really get to the point of shutting the water off if the money is not forthcoming; this leaves a large loophole.

In the cities a class of people exists who apparently live to beat the water departments, and their method of transferring property is remarkable; last year we had about 12 000 transfers of property. The amount of money lost directly through unpaid bills is insignificant compared with the large additional cost of shutting off water, doing the extra clerical work and watching the thieves, — for that is what they are. The reputable people do not bother us; it is the disreputable ones. Something must be done, and I desire you to know that Boston proposes to bring the matter up again.

I want to repeat that Mr. Hall looks at the matter in the right way; in addition to stating what is right, and having everybody agree to do it, as has been done, we must take off our coats, go to work, and get results.

MR. ALBERT L. SAWYER.† I can't see any reason why the water bill should not be a lien on property, the same as the sewer

* Division Engineer, Public Works Department, Boston, Mass.

† Water Registrar, Haverhill, Mass.

assessment or taxes. In the city of Haverhill our losses on this account are reduced to a minimum, for the reason that out of our 1 700 meters, over one half are house meters, and for those we collect yearly in advance, at the beginning of the year, so that we really run small risk. As we also give 25 per cent. discount on the water bill, this in effect collects about 95 per cent. of the bills when they are due. I should like to see another bill of this kind introduced in the legislature, and then have the members of the Association back it up as well as they did the last time. It seems to me that if a bill is introduced we might get the aid of our legal representatives, and perhaps do something to offset this lobby on the other side, and so we might get it passed. Last year such a bill was advocated by Mayor Fitzgerald, and I think that if we can get the Democrats of Boston to favor a bill we might be able to get it through.

Mr. Percy R. Sanders.* We have had about the same success in New Hampshire that Mr. Thomas had with the Massachusetts legislature. In the session of 1910 a bill was introduced similar to the one that Mr. Thomas introduced in the Massachusetts legislature. We felt that with the increase of our meters, where the rates were collectible at the expiration of the quarter, we should be able to collect the bill from the last owner. In several instances we have collected the bill from the owner where the property has changed hands during the quarter. In one case he made objections and said he didn't believe we could collect it if it came to court, and it struck us that it might be true, although we didn't tell him so. One of the members of our water board was a member of the legislature of 1910, and he introduced this bill. It was referred to the Judiciary Committee, a day was set for the hearing, and a number of us appeared before the committee and advanced all the arguments we could in favor of the bill. The arguments against the bill were substantially as the gentleman from Boston says, — that it would make trouble for the real estate dealers and the lawyers to look out for more liens. The bill was returned from the Judiciary Committee to the House with the report " Inexpedient to legislate," and that is where the matter stands now. We collect our bills the same as we did

* Superintendent Water Works, Concord, N. H.

before — that is, we take advantage of the doubt and make the owners think we can do it.

MR. HALL. Mr. President, I want to offer just one more suggestion. I was interested in the bill relating to municipal finance, which passed the legislature last year. I carried that matter before three legislatures before I got the bill passed. Before the bill was assigned I had prepared some one hundred and fifty postal cards, leaving a blank for the committee to which it would be assigned and for the date of the hearing; and I would make the suggestion that, if this matter is coming up, the committee in charge should make that preparation, and then should mail a notice to such members of the Association as they consider would be forceful in presenting the matter to the legislature, and in that way carry up 75 or 100 or 150 men, for a multitude counts, without any question, in a matter of this kind.

MR. KING. Mr. President, I move that a committee of five be appointed by the Executive Committee to take all necessary and desirable means to secure the passage of a statute in Massachusetts making water bills a lien upon real estate.

VICE-PRESIDENT SULLIVAN. I should think that the committee might be of some help in other states. I see that Mr. Sanders is looking this way. Is there anything to be said on the motion?

MR. MARTIN. Would a suggestion that Mr. Hall be chairman of that committee be in order? He seems to have had a lot of experience.

VICE-PRESIDENT SULLIVAN. I dare say that the Executive Committee will take that suggestion into consideration, or you might offer it as an amendment to the motion.

MR. MARTIN. I will move that as an amendment.

MR. KING. I will accept the amendment.

(The motion is adopted.)*

A MEMBER. I would ask if you have any idea how private companies would be affected by any such legislation.

MR. KING. If I recollect the Rhode Island law, it did not act in favor of private water companies, and they were intending to see if they could secure an extension of the law, that is, to have an amendment made which would include them.

*For the appointment of the Committee see page 553.

MR. HALL. If I can serve the Association in this capacity, I shall only be too glad to do it, and I will give you the benefit of my municipal and legislative experience freely.

SMALL WATER PURIFICATION PLANTS. A PLEA FOR THEIR MORE EFFICIENT OPERATION.

BY H. P. LETTON, SANITARY ENGINEER, U. S. PUBLIC-HEALTH SERVICE.

[*Read December 10, 1913.*]

Several interesting papers have recently appeared dealing with the operation of sewage disposal plants and emphasizing the necessity for more careful supervision of this kind of municipal work. It is well known to all who have investigated the matter that small sewage disposal plants receive as a rule little or no attention, and that their effluents could be greatly improved under proper operation. Discussion of these matters is therefore advantageous and desirable.

The writer was for some time previous to last July in the employ of the New Jersey State Board of Health, engaged mainly in the supervision of the public water supplies of the state. In connection with this work about thirty water purification plants have been visited upon numerous occasions. As a result of these visits, it became evident that the opinions that had been expressed in regard to the operation of sewage disposal plants were largely applicable to small water purification plants.

The main difference in the two cases is this: Sewage disposal plants are usually built not because there is a concerted public demand for them, but for the eradication of a local nuisance, or by order of some higher authority. Because of this fact, and because the terms "sewage" and "sewage disposal" are distasteful to the average layman, the plant is generally put in an out-of-the-way place, and either forgotten entirely or placed in the charge of an underpaid, superannuated caretaker who knows nothing of the principles upon which the design of the plant is based; while a water purification plant is generally installed as a result of a popular demand and the consumer is directly interested in its operation in so far as furnishing a clear, colorless, and palatable water is concerned. These are the qualities that to the majority of people determine the purity of the water, and as long as

they are maintained there is little or no question as to the efficiency of the plant in other ways. As a matter of fact, however, there are many plants which will usually meet the above conditions but which are inefficient both from an economic and a sanitary standpoint.

It is only on rare occasions that a filtration plant has been constructed at the time of the installation of the water-works system. In most cases, when the purification plant is added to an existing system, the operation of it is intrusted to the engineer of the old plant. This man may be, and in many cases is, a stationary engineer who thoroughly understands the operation of boilers, engines, and pumps, but who has absolutely no idea of the principles which underlie the process of water purification.

There is also another point which in many cases affects the results obtained. When it is decided that some form of purification is advisable in connection wi h a small water plant, it is very rare indeed that a consulting engineer is called in for advice. Instead, the matter is taken up with one or more companies engaged in the business of installing purification apparatus. While these companies are usually competent to give reliable advice, their main business is the selling of equipment. Because of this fact and because the usual small water company or municipality is weak financially, the filter plant is designed to fit the available money, and the company offering the equipment for the least sum is generally given the contract regardless of the quality of the material to be furnished. As a result of this practice, plants that are poorly designed, lacking in the necessary equipment for efficiency, or even wholly ill-adapted to the situation, are commonly met with. A few cases of this kind which have come under the observation of the writer will be noted. Probably the worst example was at a plant supplying about a million gallons per day. The supply was originally obtained from artesian wells, but on account of the high iron content of the water, a new supply was obtained from an artificial lake. This water was highly colored by its passage through cedar swamps. From the lake the water flowed by gravity to the coagulation basin. This was a rectangular wooden tank of such size that normally less than twenty minutes were allowed for coagulation and sedimentation. During

periods of high consumption the time was considerably decreased. The basin was set at such an elevation that at times of low water in the lake it was impossible to obtain the normal supply except by by-passing some raw water. From the coagulation basin the water flowed by gravity to four rapid sand filters of the gravity, circular wooden tank type, without loss of head gages or rate controllers. The agitating rakes were intended to be driven by a water motor, but the necessary power was lacking. The beds were therefore not agitated during washing. From the filters the water passed to a suction well which had been used in connection with the former well supply, and which provided less than thirty minutes' storage. Two solution tanks had been provided and connected with a small displacement pump driven from the line shaft to which the main water pumps were attached. The small solution pump was intended to force a solution of sulphate of alumina into the raw water just before it entered the coagulation basin. At the time of the writer's first visit to this plant the chemical pump was out of order and no chemical was being added. It was afterward learned that this was its chronic condition. Tests of the raw water showed it to be slightly acid owing probably to humic acid from the cedar swamps. Consequently the addition of sulphate of alumina would be an absolute loss as far as results are concerned. Analyses of the raw and filtered water showed no material difference, and the filtered water had at times a color as high as two hundred.

While the foregoing may seem to be an extreme case, conditions almost as bad were found in several instances. Two other plants were discovered treating acid water with sulphate of alumina only, rate controllers and loss of head gages were almost unknown, and the methods of regulating the amount of chemical applied were very crude. Few calibrated orifice boxes were found in use. Two gravity, rapid sand plants, treating waters high in organic matter and often turbid, had no coagulation basins, so that they required too frequent washing with corresponding reductions in bacterial efficiency as well as increased costs of operation. Another large plant, using the pressure type of filter, was treating a turbid water with very little time for coagulation. The effluent was frequently turbid, and at times contained aluminum hydrate.

One plant of the slow sand type had less than a foot of filtering sand, and had a clear-water well holding about a half hour's supply. As a result of this combination, the rate of filtration fluctuated exactly as the demand, and purification was practically *nil*.

At one rapid sand plant the clear-water basin was so small that it was necessary to wash with raw water. Another plant had no arrangement for filtering to waste, so that whenever it was necessary to get at the strainer system the dirty water in the bed was drained into the clear-water well.

On the matter of operation, conditions were found to be as bad if not worse. As has been said, the man in charge of a small water purification plant has usually little or no idea of the nature of the process. He operates the plant by "rule of thumb" methods in an endeavor to produce a good-looking water. Although efficient results depend so largely upon the use of the correct quantity of coagulant, the greatest ignorance was shown of this matter. At several plants the engineer stated that he put in a certain number of buckets of alum per day. He did not know how many pounds were used and made no attempt to add it in the same proportion at all times. A few engineers said that they increased the dose "some" when the water was turbid, but did not know how much. In only a few plants was any attempt made to regulate the dosage by the aid of alkalinity and turbidity tests. As a matter of fact, few of the men in charge could be depended upon to make the necessary alkalinity tests. At only two plants, treating less than twenty million gallons per day, were laboratories maintained, and at these plants the tests, both chemical and bacteriological, were made under the direction of non-resident chemists. The engineers who made the tests were unable to interpret them or apply them in the operation of the plants. At one modern municipal plant, absolutely no records were kept. The chief engineer could neither read nor write, and could see no use in records of any kind, not excepting pumpage records. The president of the board of water commissioners in charge of the plant stated that the only reason he could see for filtering water was to remove turbidity, notwithstanding the fact that the sewage of over a hundred thousand people was discharged in the

river, from which the supply was taken, about seventeen miles above the intake.

At one plant visited, it was found that through the laziness of the engineer the filters were not being washed enough, the deficiency of water due to clogging being made up by by-passing raw water. At another plant, the beds were washed too often, resulting in a low bacterial efficiency and a high cost of operation. Over ten per cent. of all water filtered was being used for wash water.

It is not believed that such cases are confined to New Jersey. Reports of investigations in Ohio, Pennsylvania, New York, and Illinois show very similar conditions. Much as they are to be deplored, the fact remains that they do exist, and that a discussion of possible remedies is in order.

The most feasible remedy for poor design is a statute requiring the submission of plans for proposed plants or changes in existing plants to the state board of health, or some other state authority, for approval before construction can legally be carried out. Such a regulation is in effect in a number of states at the present time. Coupled with the appointment of a properly qualified engineer to pass upon all plans, it will satisfactorily care for new works. State supervision for existing plants will if carried out do much to remedy the more serious imperfections of construction and operation. This supervision cannot, however, be thorough enough to furnish definite information for the efficient operation of the plant both from an economic and a sanitary standpoint. At best the plant can be visited only about once a month, and this visit is merely to see that a safe and potable water is being produced. From the viewpoint of the state this result is sufficient, but from that of the consumer and taxpayer there are other matters of great importance. He wishes to know, first, that the water is healthful, and then, that it is not possible to obtain the same or better results at a less cost by some change in the method of construction or operation of the plant. This latter is out of the field of the state inspector, for it generally requires much experimenting and testing to obtain the point of maximum efficiency.

The plan of having the engineer at the plant make daily tests under the general direction of a consultant at a distance is a step

in advance, but it is far from perfect. The engineer's results are open to question since he is often hurried and makes the tests without knowing the reason for the various steps. Also, since he has but infrequent consultations with the consulting engineer or chemist and is unable in most cases to explain any seeming discrepancy in his results, they do not prove to be of as much value as might be expected.

The writer has had in mind for some time a plan for remedying this situation, and it has recently again been brought to his attention by a similar plan which Prof. Earle B. Phelps has put into operation in connection with local health administration in several small Massachusetts towns. The plan is this: For several water companies or municipalities located not too far apart to combine forces, fit up a laboratory at some central point, and employ a competent bacteriologist and chemist to give his entire time to the scientific supervision of their water plants. By so doing, each plant would have the benefit of expert advice at a small cost. It would be possible for the chemist to visit each plant one or more days each week, and by so doing to become familiar with its operation. He could instruct the engineer in charge of the plant how to make the necessary daily chemical tests, such as alkalinity, turbidity, etc., and since he visited the plant so often, these results could be checked up and would be reliable. In case of emergency he would be able to look after the sanitary quality of the water and thus protect the consumer. He would be able to carry on experiments upon the proper amount of coagulants to be used, and time of coagulation. There is a chance for much study in the manner of washing the filters to bring about efficiency and economy. This is a point not considered much in small plants, but which has a considerable bearing on the cost of operation. It requires many visits to a plant to become familiar with its operation and to suggest changes which will increase its bacterial efficiency without increasing the cost. It is believed that the scheme outlined would in many cases save money for the water company or municipality, besides giving them and their consumers confidence that the quality of the water was being safeguarded.

DISCUSSION.

MR. PAUL HANSEN (*by letter*).* Mr. Letton has presented a most striking picture of the manner in which the typical small water purification plant is neglected, and his suggestion for a remedy, namely, the establishment of laboratories at convenient points to serve two or more small purification plants, is a most excellent one. In practice, however, this is rather difficult of accomplishment, especially in the Middle West and Far West, where the distances between purification plants are rather great. Moreover, the difficulties, legal and otherwise, of securing co-operation in this way are almost insurmountable.

Mr. Letton has made a statement regarding the employment of a consulting engineer in connection with operation, and this, in my opinion, gives the clew to the practical and early solution of not only the management of the purification works but also the management of the entire water-works plant, including oversight of the finances and methods of accounting. In recent papers before the Western Society of Civil Engineers and the Illinois Society of Engineers and Surveyors, I advocated the employment on an annual basis of consulting engineers by small communities for the purpose of supervising water-works operation, including the operation of purification works. Such service could be obtained at very small expenditure, comparatively speaking, probably not exceeding six hundred dollars per annum for a small water-works plant in a town of not less than ten thousand population.

The advantages of this arrangement would be as follows:

(1) The public would receive better service.

(2) The cost of operation will be reduced, which means increased earnings.

(3) Future requirements will be anticipated, and thereby the water-works plant may be always kept in readiness to meet demands upon it. There are a number of instances in the state of Illinois where water supplies have failed and machinery has proved inadequate merely due to lack of foresight in anticipating what the future would bring forth.

* Engineer, Illinois State Water Survey.

(4) The design of water works will be improved for the reason that the supervision by consulting engineers will give these engineers an opportunity to observe the manner in which their designs "work out" and enable them to appreciate the value of a great number of important details which in present practice are often overlooked. In short, the design and operation go hand in hand, and it is not possible for an engineer to master one without knowing a great deal about the other.

(5) A professional and personal advantage to engineers will result. The professional advantage relates, as already suggested, to the opportunity to acquire better knowledge of the problems before them, thereby rendering their services of greater value. It would also enable them to maintain a more efficient office organization, for with present methods it frequently becomes necessary for engineers to dispense with the services of some of their best men during periods when work is slack. The personal advantage relates to the increased income of consulting engineers, but this is a very minor consideration compared with the good to the general public that may be accomplished by thus increasing the scope of the consulting engineers' work.

PROF. GEORGE C. WHIPPLE (*by letter*).* The operation of the small water purification plant is indeed a difficult problem. The reason is that the attention required is the same in kind as that for a large plant, while the cost of proper supervision becomes disproportionately large when the quantity of water filtered is small. To keep this cost down it is customary to employ untrained operatives, and the result is that, as the author says, small plants are often badly conducted.

Where several small plants are near together, the plan of securing coöperation between them, each contributing to the support of a capable supervising engineer, would appear to be a promising one. Such a plan has been in operation in the water department of the city of New York for many years, although in this case the various plants are owned by the same authority, although scattered in location. The same general scheme is followed by some of the large water-works companies which control many plants that are still more widely scattered. Somewhat similar in character

* Professor Sanitary Engineering, Harvard University.

is the control exercised by state departments of health over the filter plants within their jurisdiction.

The difficulty with this plan is that the filters must operate all the time, while with any system of coöperation the supervisor's work is intermittent. The real dangers from filters may be said to be due to emergency troubles. Most filters work well most of the time. The best filters work well all of the time. The poor filters work badly on occasions, and the more frequent these occasions, the less safe is the filtered water. After all, it is the laborer in charge of the plant who needs to understand his job, for it is usually his hand that is at the throttle when things go wrong. At such time analytical work counts for nought and it is the horse-sense of the man on the spot that must be depended upon.

It must be recognized that the small plant must be operated at small cost, and in the writer's opinion the safety of such plants must lie in the education of the low-salaried attendant and in the selection of such sources of supply that irregularities in operation will produce less disastrous results than in the case of larger plants where a higher grade of supervision is possible. To secure the better appreciation by the operator of the general principles of sanitation, and a better understanding of the work which a particular filter is capable of doing, the supervision of the state authorities should be not so much punitive as pedagogical.

Mr. Letton also calls attention to the fact that small plants are apt to be "commercial" or "stock" plants rather than "specially designed plants." This also conduces to poor operation because the stock pattern may not be suited to the local conditions. All this is quite natural, but it is unfortunate. It is difficult to make small communities see that it pays for them to secure adequate advice in the beginning from persons not interested in selling goods. It almost goes without saying that a filter that is well adapted to local conditions can be depended upon to furnish regularly a better supply of water than one that is not, and the poorer the grade of operation, the more important is it that the filter be well adapted to its work.

When all things are considered, the surprising thing is not that the small plants are so badly operated, but that the protection

of the health of the people by the use of such badly run plants has been so good as statistics in many places have shown it to be.

Mr. Robert Spurr Weston (*by letter*).* To the author's examples of ignorance and carelessness of filter attendants and the unsuitableness and inadequacy of purification plants, the writer could add many others. Many a plant has been put in to satisfy a popular demand, or as a concession in a trade between corporation and city, hence the plant often is a name rather than a device producing safe and attractive water, and its operation is left, as Mr. Letton intimates, to the tender mercies of the untaught.

The writer's experience with the men at the ordinary small pumping station, say of less than one million gallons daily capacity, has been happier than Mr. Letton's and he has gained much by association with such men at plants represented in this Association. For example, one man at a station in a town of less than ten thousand has learned to make the ordinary analytical determinations, to operate a plant handling a water difficult to purify, and to inform himself by persistent reading of suggested books and of the reports of the Massachusetts State Board of Health of the fundamental principles and some of the fine points of water purification. Generally the writer has found these men teachable, — more than that, eager to learn.

But to make a filter attendant and analyst out of a water-works employee inplies a teacher, and the writer is somewhat in doubt as to the best method to be employed. The possibilities are limited by the money available, which is less than the salary of a young analyst, — say, less than nine hundred dollars a year. Usually no small works can afford to pay over five hundred dollars a year for part-time services. Whether this amount paid by each of say three water works to a single filter superintendent, as suggested by Mr. Letton, or to an office employing several specialists, as suggested by Mr. Hansen, will yield better results, is still an open question. Personally, the writer feels that the judgment of an experienced consultant upon the observations of young engineers, chemists, and bacteriologists is more valuable than the service which could be rendered by one man in a central

* Consulting Sanitary Engineer, Boston, Mass.

laboratory for the same money. The fee for the consultant is very small for the service rendered, and is so because of the statistical information which because of his connection with the works is available for use in his practice. There is nothing to prevent the establishment of a central laboratory by the consultant. There is room for Mr. Letton's plan, and the writer hopes it will be tried out. The principal difficulty in the way of all plans of this kind is the location of the purification plants.

In larger places it is possible to make arrangements for the whole time of a young trained assistant, who is trained, sent out, and advised by some consulting office. This plan makes available the services of the consultant for a very low fee. The assistant would ordinarily hold such a position for a year or two and be supplanted by another trained in the consultant's office, and who probably had been engaged previously at some smaller plant on part-time service.

Mr. Letton has called attention to a glaring defect in one of the most important public-health services, and the writer hopes that his interesting paper will assist in remedying it.

The furnishing of the necessary professional service does not seem to the writer to be so difficult as to persuade works owners and managers that such service is necessary, and if so, to persuade them to pay for enough of it to safeguard the quality of their product. Fortunately, however, it is sometimes possible to effect economies in operation which compensate for part or all the cost of expert assistance.

Mr. Earle B. Phelps (*by letter*).* The writer fully agrees with Mr. Letton that the conditions described by him are in nowise extreme nor are they confined to the state of New Jersey. With our present development of the art of design and operation of water plants, and especially those plants which rely upon some form of chemical treatment, there exists an entirely inexcusable neglect of the equally important matter of daily operation. This is a matter of such common knowledge that it is unnecessary to dwell upon it further.

We turn with interest, therefore, to the remedies which are proposed. The writer has had practical experience with the practice

* Consulting Sanitary Expert, New York.

described by Mr. Letton of employing a consulting expert to have a general oversight of the plant and its operation. It was his custom for some time to receive daily reports from several such plants that were under his supervision, such reports including the simple chemical and bacteriological tests which the engineer in charge had been taught to make. Monthly visits to the plant and a monthly report to the water board were made. While such a system of supervision is far in advance of the ordinary procedure, it is without doubt subject to the difficulty which Mr. Letton has pointed out.

A particular weakness which may develop at any time and against which there seems to be no positive remedy is actual dishonesty on the part of the engineer who is supposed to make tests. The fact that the results remain fairly uniform day after day may suggest the idea that the record is just as valuable if the tests were not actually made. The consulting engineer may be caused rather serious embarrassment because of his reliance upon the accuracy of these reports.

The writer is especially interested in the suggestion of a more close and more scientific supervision of these plants through a coöperative working agreement. The feasibility of such a plan has been fully demonstrated in some coöperative work along the line of general board of health administration to which Mr. Letton has referred. A small group of towns in the vicinity of Boston have engaged the services of a staff of experts in the various lines of board of health administration and during the past year have obtained the services of trained workers in these various lines at a cost which is within their means, although the cost to any single town would have been prohibitive. The same principle holds in the case of small water plants. A small portion of the services of the expert will suffice at any one plant so that it is quite feasible to divide his time among a number of plants within easy traveling distance. The chief difficulty in such a plan as this lies in the distribution of expenses and of the expert's time. There is also opportunity for confusion of authority and, in the case of our board of health work at least, a tendency on the part of the various parties interested to expect rather more than their just share of the service.

The matter of division of expenses has been regulated by a definite agreement and contract between the writer and the individual towns in such a way that, while the movement as a whole is coöperative, the towns deal with only one man upon a strict contract basis. No town, therefore, has any right to question whether it is paying too much of the general cost of the work, although even now such a question does arise.

The distribution of services is a somewhat more difficult matter, especially in board of health work where the only limit to the amount of work that can be done is fixed by the available time and men. We have handled this matter somewhat arbitrarily, relying wholly upon a systematic time card, on the basis of which we are able at the end of the year to show each town what proportion of the total work of the staff has been devoted to their individual needs. In this manner, while we have not entirely escaped criticism, we have been able to apportion the services rendered to the incomes received from the various communities, with reasonable fairness.

It will be exceedingly difficult for any group of towns to mutually agree upon a proper distribution of expenses in an undertaking of this kind. The only hope of successful application to the water-works problem lies in an individual agreement between the expert and the various authorities, or, perhaps better still, in the state or other central authority initiating this work nominating or approving the appointee and arbitrarily apportioning the cost.

PROCEEDINGS.

HOTEL BRUNSWICK,
BOSTON, MASS., November 12, 1913.

Vice-President William F. Sullivan in the chair.
The following members and guests were present:

HONORARY MEMBER.

William T. Sedgwick. — 1.

MEMBERS.

S. A. Agnew, A. F. Ballou, L. M. Bancroft, G. W. Batchelder, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, E. C. Brooks, F. H. Carter, J. C. Chase, R. D. Chase, W. F. Codd, F. L. Cole, A. O. Doane, L. R. Dunn, E. D. Eldredge, G. F. Evans, F. L. Fuller, Patrick Gear, F. J. Gifford, A. S. Glover, F. H. Gunther, R. K. Hale, F. E. Hall, J. O. Hall, A. R. Hathaway, T. G. Hazard, Jr., D. A. Heffernan, J. L. Howard, A. C. Howes, J. L. Hyde, Willard Kent, Patrick Kieran, G. A. King, F. A. McInnes, J. A. McMurry, A. E. Martin, John Mayo, F. E. Merrill, H. A. Miller, William Naylor, F. L. Northrop, T. A. Peirce, H. E. Perry, Dwight Porter, L. C. Robinson, H. F. Salmonde, P. R. Sanders, C. M. Saville, A. L. Sawyer, G. A. Stacy, G. T. Staples, E. L. Stone, W. F. Sullivan, H. L. Thomas, R. J. Thomas, W. J. Turnbull, F. E. Tupper, W. H. Vaughn, F. B. Wilkins, F. I. Winslow, G. E. Winslow. — 62.

ASSOCIATES.

Ashton Valve Company, by H. H. Ashton; Builders Iron Foundry, by F. N. Connet and A. B. Coulters; Chapman Valve Manufacturing Company, by J. T. Mulgrew; Darling Pump and Manufacturing Company, by H. M. Pickersgill; Hersey Manufacturing Company, by Albert S. Glover; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by A. R. Taylor; H. Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by J. G. Lufkin and H. L. Weston; National Water Main Cleaning Company, by B. B. Hodgman; Neptune Meter Company, by R. D. Wertz; Pittsburgh Meter Company, by J. W. Turner; Platt Iron Works Company, by J. H. Hayes; The Pratt & Cady Company, by Charles E. Pratt; Rensselaer Manufacturing Valve Company, by C. L. Brown; A. P. Smith Manufacturing Company, by F. L. Northrop; Standard Cast Iron Pipe and Foundry Company, by W. F. Woodburn; Thomson Meter Company, by E. M. Shedd; Union Water Meter Company;

by E. K. Otis; Water Works Equipment Company, by W. H. Van Winkle, Jr.; R. D. Wood & Co., by H. M. Simons; Henry R. Worthington, by Samuel Harrison and E. P. Howard. — 25.

GUESTS.

Nathan C. Rockwood, assistant editor *Engineering News*, Fred W. Schultz, *Engineering News*, and D. A. Decrow, New York, N. Y.; C. J. Callahan, Lewiston, Me.; F. N. Strickland, assistant superintendent water works, Westfield, Mass.; Francis Sears, Plymouth, Mass.; Harry Greenalgh, Fall River, Mass.; Prof. L. J. Henderson, assistant professor, Harvard University, Cambridge, Mass.; D. J. Higgins, superintendent water works, Waltham, Mass.; and R. Forrest, Randolph, Mass. — 10.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee: Joseph A. Rourke, Boston, Mass., mechanical and civil engineer; Joseph Walton Ellms, Cincinnati, Ohio, superintendent Cincinnati Filter Plant; Moses J. Look, Brown Station, N. Y., with New York Water Works as general superintendent for contractor; Arthur E. Walradt, New Rochelle, N. Y., lawyer representing sewer and water-works corporations; H. A. Von Schon, Detroit, Mich., consulting hydraulic engineer.

On motion of Mr. Albert L. Sawyer, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duty elected members of the Association.

The Secretary read the following:

"The American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers, extend to the officers and members of the New England Water Works Association a most cordial invitation to attend and to participate in the proceedings of the International Engineering Congress to be held in connection with the Panama-Pacific International Exposition, September 20 to 25, in the year 1915, in San Francisco, California."

On motion of Mr. Lewis M. Bancroft, it was voted that the application be received and placed on file.

MR. GEORGE A. STACY. It seems, under the circumstances, Mr. President, that it is desirable, or will be desirable, to increase

the number of the committee on water purification and statistics. I therefore move that the President of the Association be authorized to make such addition to the committee as seems to him desirable. (Adopted.)

The first paper of the afternoon was entitled "Cleaning Water Mains in Hartford, Conn.," by Caleb Mills Saville, chief engineer, Board of Water Commissioners, Hartford, Conn. The paper was discussed by Mr. Frank L. Fuller, Mr. Burt B. Hodgman, chief engineer of the National Water Main Cleaning Company, Mr. Edwin C. Brooks, Mr. Frederic I. Winslow, and Mr. William F. Codd.

"Water and Life" was the subject of a paper by Lawrence J. Henderson, M.D., professor of biological chemistry, Harvard University. Professor Sedgwick and Professor Porter followed with brief remarks.

The subject for topical discussion was "Advisability of Securing Legislation for Making Water Bills a Lien upon the Property Supplied." The following-named gentlemen participated in the discussion: Robert J. Thomas, A. R. Hathaway, George A. King, Arthur F. Ballou, Lewis M. Bancroft, Frank L. Fuller, John O. Hall, Frank A. McInnes, Alfred L. Sawyer, and Percy R. Sanders. At the close of the discussion it was voted that the Executive Committee be directed to appoint a committee of five, with John O. Hall, of Quincy, as chairman, to take all necessary and desirable means to secure the passage of a statute in Massachusetts making water bills a lien on real estate.*

Adjourned.

HOTEL BRUNSWICK,
BOSTON, MASS., December 10, 1913.

J. Waldo Smith, President, in the chair.

The following-named members and guests were present:

HONORARY MEMBERS.

Frederic P. Stearns and William T. Sedgwick. — 2.

* For the appointment of the committee see page 553.

MEMBERS.

N. W. Akimoff, S. A. Agnew, M. N. Baker, L. M. Bancroft, R. D. Barnes, H. K. Barrows, G. W. Batchelder, C. R. Bettes, A. E. Blackmer, J. W. Blackmer, George Bowers, G. A. Carpenter, E. J. Chadbourne, R. D. Chase, J. H. Child, R. C. P. Coggeshall, F. L. Cole, M. W. Davenport, J. C. DeMello, Jr., John Doyle, H. P. Eddy, E. D. Eldredge, G. F. Evans, F. F. Forbes, A. S. Glover, J. M. Goodell, F. H. Gunther, R. A. Hale, R. K. Hale, F. E. Hall, J. O. Hall, E. A. W. Hammatt, T. G. Hazard, Jr., Allen Hazen, D. A. Heffernan, A. C. Howes, F. J. Hoxie, W. S. Johnson, Willard Kent, G. A. King, F. H. Luce, A. E. Martin, John Mayo, J. H. Mendell, F. E. Merrill, H. A. Miller, J. J. Moore, William Naylor, A. S. Negus, F. L. Northrop, T. A. Peirce, Dwight Porter, H. E. Royce, P. R. Sanders, H. W. Sanderson, A. L. Sawyer, W. P. Schwabe, J. Waldo Smith, G. A. Stacy, W. F. Sullivan, R. J. Thomas, E. J. Titcomb, D. N. Tower, G. W. Travis, C. H. Tuttle, W. J. Turnbull, W. H. Vaughn, F. P. Washburn, F. B. Wilkins, F. I. Winslow, G. E. Winslow, H. B. Wood, I. S. Wood. — 73.

ASSOCIATES.

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GUESTS.

Fred Cole, Frank E. Davis, William Grant, and E. P. Howard, Boston, Mass.; James Pintech, East Greenwich, R. I.; George W. Bowers, Lowell, Mass.; Albion Davis, Waltham, Mass.; Hiram C. Jenks, Pawtucket, R. I.; C. C. Covert, Albany, N. Y. — 9.

THE PRESIDENT. It is with great regret and sadness that I have to announce that during the past week our old friend and member, Mr. Horace G. Holden, has passed on.

Out of respect to his memory, and in consideration of the fact that he was one of the charter members of this Association, I will ask you all to stand and observe a moment's silence.

The President's suggestion was followed, and all stood in silence.

Mr. R. C. P. Coggeshall. Mr. President, early in the year of 1882, the month of February, I had occasion to go to the city of Lowell to look up some matters in connection with water-works experience. At that time I first met Horace G. Holden. At the same time Mr. Frank E. Hall was there, and a delightful acquaintance commenced on that day. Later in the day we all three went to Lawrence, and there met Mr. Henry W. Rogers, who was then the superintendent. We four men at that time discussed the possibility of an association, — not as large as this, for we never dreamed it, but an association that would meet in Boston occasionally, once a month or so during the winter, and have a dinner and a talk. Each one of us four, aided by Mr. Albert S. Glover, who afterwards came in and did a tremendous amount of work, were charter members of this Association, which held its first meeting June 21, 1882. Of the seventeen charter members of the Association, there are four survivors, — Mr. Hall, Mr. Glover, and myself, and Mr. Richard W. Bagnell — who at the advanced age of ninety-two is in good health and living in Plymouth, Mass.

We all remember Horace Holden for his cheery face and kindly smile. He was always the same man in all the years that I knew him. We shall miss him much, and peace be to his memory.

Mr. President, at this time I would suggest that a committee be appointed to prepare an appreciation of Mr. Holden for the pages of our Journal.

Mr. George A. Stacy. Mr. President, I move that the committee shall consist of the four surviving charter members of the Association.

The President put the motion, and declared it unanimously adopted and the committee appointed.

The Secretary presented applications for membership, duly recommended and endorsed, from Hiram C. Jenks, Pawtucket,

R. I., engaged in making surveys for underground sources of water supply; Sheldon S. Yates, Cambridge, Mass., instructor in civil engineering, Harvard Graduate School of Engineers; F. A. Dallyn, Toronto, Ont., engineer in charge of experimental station in 1910, Provincial Board of Health, Ontario, 1913, provincial sanitary engineer, 1913; Scotland G. Highland, Clarksburg, W. Va., secretary and general superintendent of the water works and sewerage systems of Clarksburg, W. Va.; C. R. Elder, Amherst, Mass., for ten years general superintendent and constructor of water-works plants and railroad water supplies, for past eight years superintendent of the Amherst Water Company.

On motion, the Secretary was directed to cast one ballot in favor of the admission of the applicants, and he having done so they were declared duly elected members of the Association.

The first paper of the afternoon was by X. H. Goodnough, chief engineer of the Massachusetts State Board of Health, on "Rainfall." The paper was illustrated by diagrams showing variations in rainfall for different periods. Before reading his paper, Mr. Goodnough said:

This paper was begun with the idea of collecting all of the rainfall records available in New England, also the record of flow of streams. It was a scheme that I began with Mr. Safford, and we hope some day to complete it. Much of the work of collecting records and analyzing them has been done by Mr. R. M. Whittet, of the State Board of Health, and the diagrams by Mr. Crowhurst of the same office.

Mr. Goodnough's paper was discussed by Mr. Winslow, Mr. Allen Hazen, and Mr. Fitzgerald.

Mr. N. W. Akimoff, Philadelphia, Pa., presented a paper entitled "On Flow in Bends." This paper was also illustrated.

The third paper on the program for the afternoon was entitled "Small Water Purification Plants, a Plea for Their More Efficient Operation," by H. P. Letton, sanitary engineer, Washington, D. C. Mr. Letton was unable to be present, but sent as his representative, Mr. Grant, of Nebraska, who read the paper. The paper was discussed by Mr. Earle B. Phelps and by Mr. G. C. Whipple, in writing.

It was voted that the topical discussion on "A Comparison of

Methods Used to Locate Hidden Leaks in Underground Pipes, with Special Reference to Pipe whose Actual Location is Unknown" be put over till the February meeting.

MR. JOHN O. HALL. Mr. President, I would like to make a request at this time of the superintendents who are present now, asking them to assist the committee to which was referred the proposed legislation for making the water bills liens upon real estate. Will they please send to the headquarters of the Association, addressed to Mr. John O. Hall, the total amount of their water revenue, and also the amount uncollected by reason of failure to obtain it from the tenant of the estate; not only the amount lost, but the amount that has delayed collection and increased expense in court. The total of that amount will be an important factor in securing the legislation which we desire, and I trust that all superintendents of water works present will get that information in at as early a date as possible. This request will also be made at the January meeting, so that our case may be in shape when we present it to the legislature.

MR. COGGESHALL. Mr. President, I believe that important information would be better collected for Mr. Hall by having a circular prepared and sent out by the Association, so that each question can be answered right on the blank and returned to him. I think in that way he will get better results than he would by trusting to the memory of the gentlemen present.

MR. HALL. Mr. President, my idea in making that announcement now was to save work for the clerk, and also expense to the Association. We shall probably have to send that blank, but I thought that we could save expense by first ascertaining to whom we must send in order to get the information.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association was held at the rooms of the Association, Tremont Temple, Boston, Mass., Wednesday, November 12, 1913, at 11.30 A.M.

Present, Vice-President William F. Sullivan and members Samuel A. Agnew, Lewis M. Bancroft, Richard K. Hale, George A. King, and Willard Kent.

The present Committee to look after and keep track of legislation and other matters pertaining to the Conservation, Development, and Utilization of the Natural Resources of the Country, namely, Messrs. M. N. Baker, William T. Sedgwick, Leonard Metcalf, Allen Hazen, and George A. Soper, were, by unanimous vote, authorized to represent the New England Water Works Association as delegates to the Fifth National Conservation Congress to be held in Washington, D. C., November 18, 19, and 20, 1913.

Invitations from New York and Atlantic City to hold our next annual convention in those cities were referred to the Executive Committee of the Association for 1914.

The Secretary was duly authorized to procure a new typewriting machine.

WILLARD KENT, *Secretary.*

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association was held at headquarters, Tremont Temple, Boston, Mass., December 10, 1913.

Present, Vice-President William F. Sullivan, and members Lewis M. Bancroft, Samuel A. Agnew, Richard K. Hale, George A. King, and Willard Kent.

Voted, That John O. Hall, Frank A. McInnes, Robert J. Thomas, George A. King, and A. R. Hathaway be, and hereby are appointed, a committee to secure legislation necessary to make water bills a lien on property.

Five applications for membership were received, viz.:

For members: Scotland G. Highland, secretary and general superintendent Clarksburg Water Works and Sewerage Board, Clarksburg, W. Va.; F. A. Dallyn, provincial sanitary engineer, 137 Geoffrey Street, Toronto, Ontario; Sheldon S. Yates, instructor in civil engineering, Harvard Graduate School of Engineering, Pierce Hall, Cambridge, Mass.; Hiram C. Jenks, surveyor for subterranean sources of water supply, 8 Manchester Street, Pawtucket, R. I.; C. R. Elder, superintendent Amherst Water Company, Amherst, Mass.;

and the applicants were by unanimous vote recommended for admission to membership.

Voted, That William F. Sullivan, Richard K. Hale, and Willard Kent be, and hereby are constituted, a committee to procure a design for certificate of membership.

WILLARD KENT, *Secretary.*

OBITUARY.

HORACE GAGE HOLDEN, previous to his decease one of the five living charter members of this Association, died at his home in Nashua, N. H., on December 7, 1913. He was born at Concord, Mass., on October 29, 1838. He was the son of Frederick Artemus and Hannah (Page) Holden. On May 24, 1862, he married Ruthanna, daughter of David and Mary (Sawyer) Butterfield, of Tyngsboro, Mass., who survives him. Three children were born of this marriage: Frank, who died in 1872; Frederick Artemus Holden, now living in Nashua, N. H., and Ida, now the wife of Col. Charles S. Proctor, of Lowell.

Horace G. Holden attended the public schools of Lowell, and after finishing with the high school of that city entered the office of the distinguished engineer James B. Francis, Esq., at Lowell. Here from 1858 to 1863 he was engaged at various duties connected with hydraulic engineering, prominent among which was the gaging of flows of water allotted to the various corporations. In October, 1863, he located at the easterly portal of the Hoosac Tunnel, and assumed the position as superintendent of construction of the easterly section of that work. Here he remained continuously until January, 1870. We are not informed in regard to his activities in the years which follow 1870 until May, 1879, at which time he became superintendent of the Lowell Water Works. Here he remained for eight years.

During the year 1887 he entered the employ of Turner, Clark & Rawson, of Boston, who were engaged in financing various waterworks enterprises in the West. Mr. Holden became their active superintendent, and was located at Minneapolis, Minn., for a few months. October, 1887, he was offered the superintendency of the Pennichuck Water Company, of Nashua, N. H., which he immediately accepted. He held this position until October, 1906,

when he resigned. From that time until the date of his death he did not resume any active employment.

The name of Horace G. Holden will always remain important in the annals of this Association. He was a lively member of that little group who worked so assiduously to effect the successful organization of this society in 1882. He served this Association upon its Finance Committee in 1882–83; was a member of the Executive Committee, 1895 to 1897 and 1902 to 1904; was Vice-President, 1883–85 and 1889–90, and was President, 1891–92. The detailed story of his work in this Association has been told heretofore and does not now require repetition. Suffice it to say that he remained an active and loyal member to the end of his days.

A member of his family recently remarked that his strong characteristics could be summed up in two words, "homespun" and "generous." Homespun he certainly was. The old-fashioned New England mode of living appealed to him strongly, and he had no sympathy with the artificialities of modern society. Never was a man more generous, and it gave him exceeding joy to share by word and deed with those he loved. He was blessed with the best of health until the decline which appeared a few months ago. He had a most cheery spirit which drew friends to him wherever he went. The value of such a life is no more to be measured than the sunshine, for like the sunshine it brought joy to those with whom he came in contact, and its wholesome influence will endure long beyond the sunset.

Peace be to his memory.

R. C. P. Coggeshall,
F. E. Hall,
R. W. Bagnell,
Albert S. Glover,
Committee.

JOURNAL

OF THE

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VOLUME XXVII.

1913.

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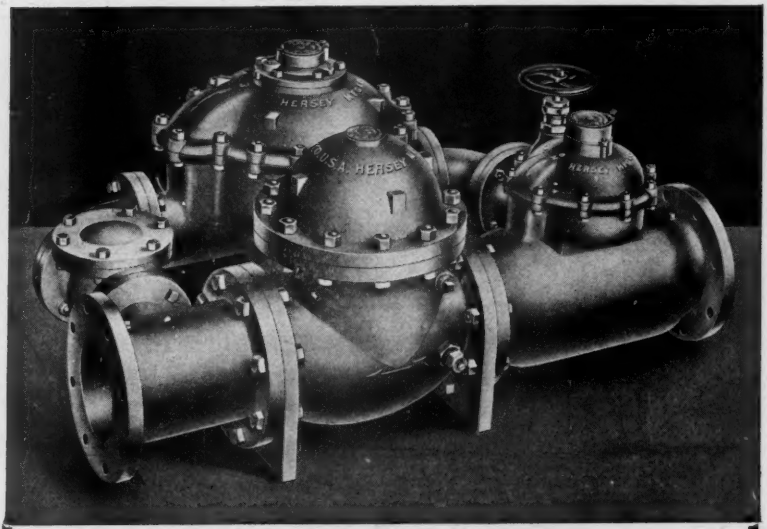

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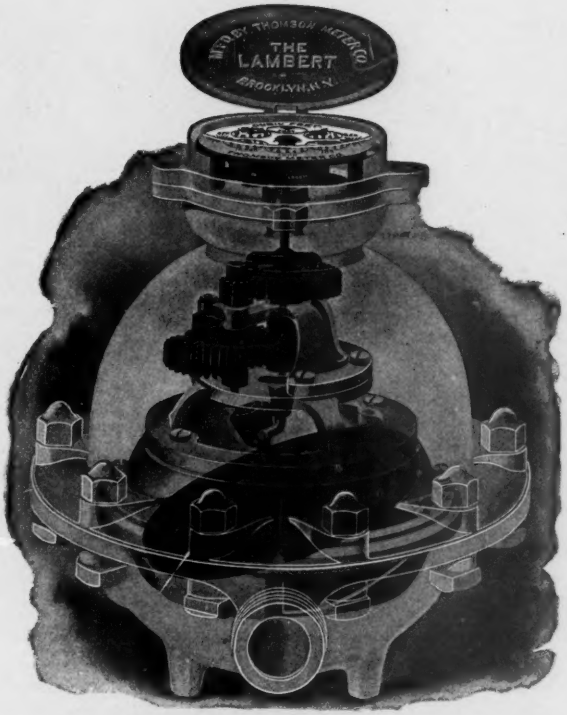

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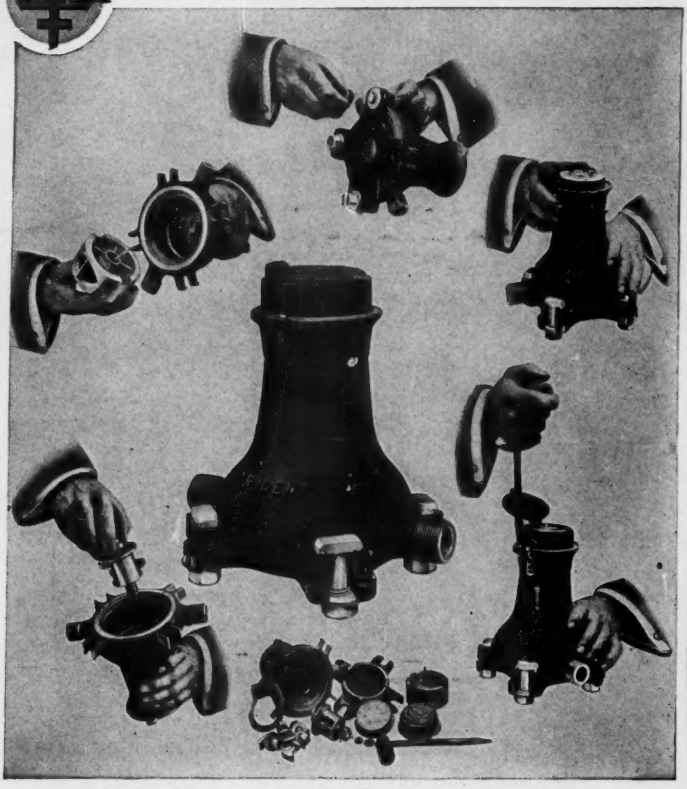

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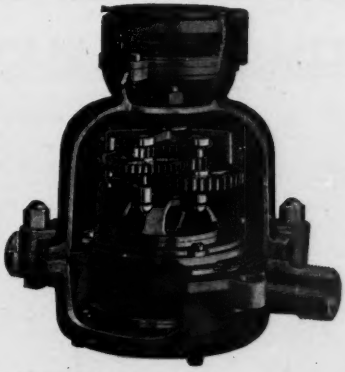

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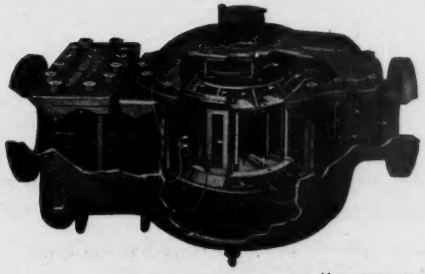

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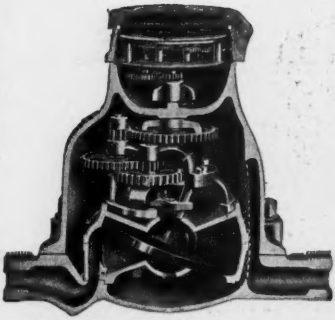

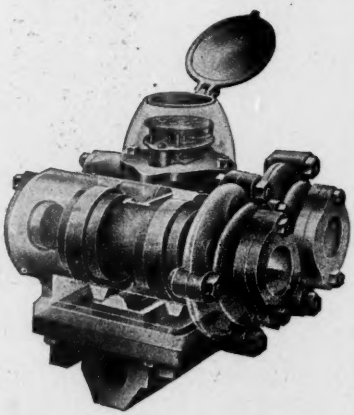

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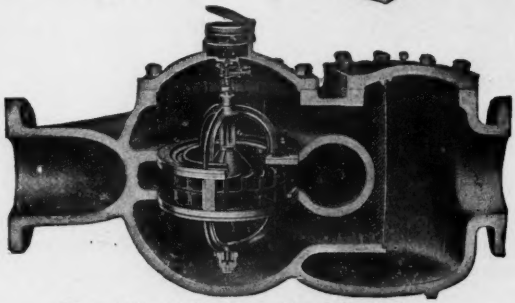

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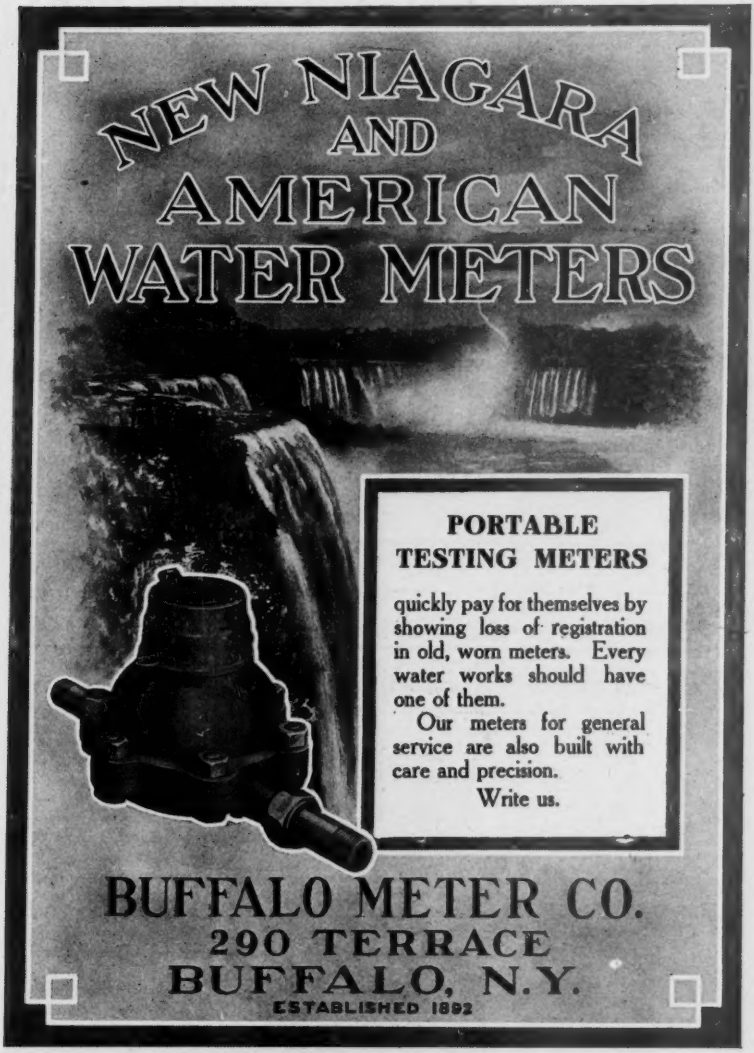
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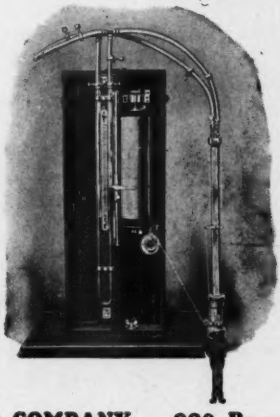

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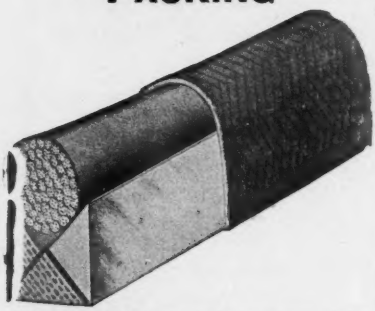

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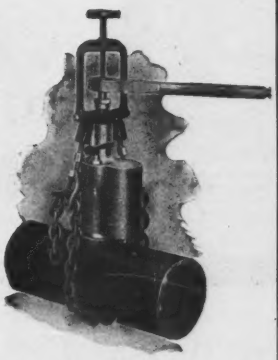

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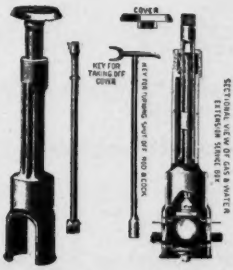

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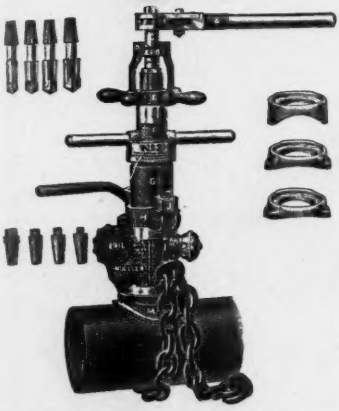

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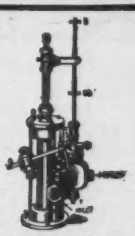

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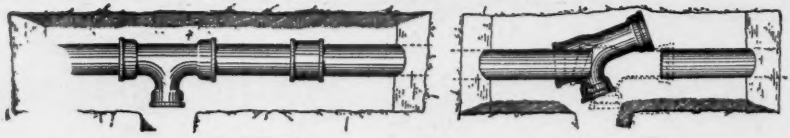
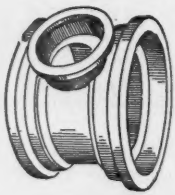


Old Way *Our Way*



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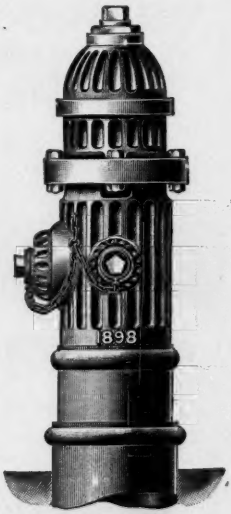

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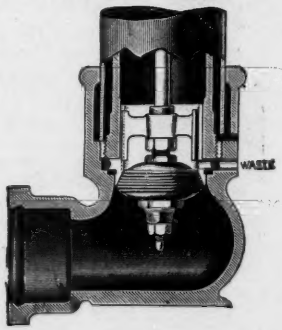
A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.



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DOUBLE DISK
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EXTRA WEIGHT, FINISH
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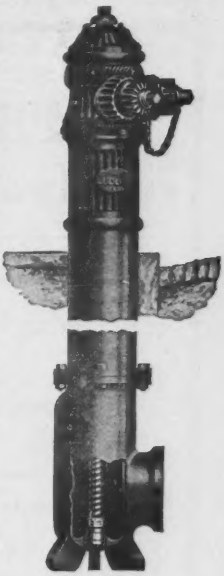

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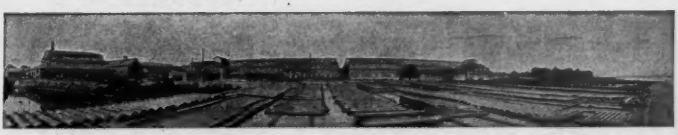

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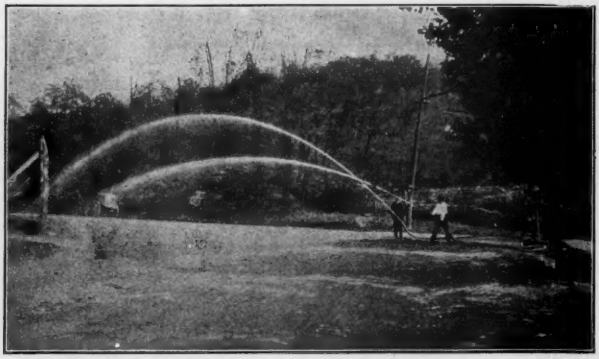

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for their service connections

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For calking pipe joints under the most difficult conditions.

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But it had a big duty to perform, so, to avoid the Import Tax, it came in the form of a formula — *D. R. Dampf-Kessel-Mischung* is what the Germans call it. Translated into boiler talk this means

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And that it does "'Raus Mit 'Em" is proved by the fact that in Germany and Europe eleven large factories are taxed to their full capacity in supplying the enormous demand.

Perolin German Boiler Compound

was first introduced in this country two years ago. During this short period it certainly has lived up to its home reputation, for the names of over 4,000 customers are on our books to-day, and they use *Perolin* exclusively.

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Perolin will increase the efficiency of your plant and lessen the labor of the fireman, by solving the scale problem at a lower cost than any other known method.

Write for a copy of "It Doesn't Affect the Water," which tells all about our proposition and the guarantee that we insist upon making.

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FOR

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Hydraulically and electrically operated valves and sluice gates Valves designed for all kinds of service.

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